THE SCIENTIFIC MONTHLY

FEBRUARY, 1942

ARTISTIC DEVIATION AS AN ESTHETIC PRINCIPLE IN MUSIC

By Dr. CARL E. SEASHORE

RESEARCH PROFESSOR OF PSYCHOLOGY, UNIVERSITY OF IOWA

THE purpose of this article is to indicate some of the approaches to the scientific investigation of an art principle in musical esthetics.

DESIGN

Esthetics in the past has dealt primarily with the composer's design, the musical form, which comes to us in the conventional score. But this score has a number of limitations. First, while it indicates pitch and time in definite notation, it has no significant dynamic notation for individual notes; and while the quality of the tone is set in part by the harmony and the choice of instrument, the score has practically no note-to-note nomenclature for the quality of tone the composer desires from voice or instrument. In other words, the composer has only fragmentary means of indicating to the performer what he himself would do or would require. The score is certainly a very inadequate blueprint for the artist's performance. Yet the design which is cast in musical form is the basic contribution to the embodiment of beauty in music.

Second, true pitch and exact time or rhythm as indicated with precision in the score would make very poor music if followed mechanically. No good singer or instrumental soloist stays on true pitch as indicated by the score, even for a fraction of a second, and only in the sense of having a basic temporal reference does he perform in metronomic time. Regarding loudness, or volume, and timbre, or tonal quality, the performer has almost complete freedom as the score says little or nothing about them. The reason for this musical license is that beauty in the rendition of a composer's design lies most frequently in the artistic play with deviations from the regular—true pitch, even loudness, metronomic time or pure tone, or any of their combinations or derivatives. Here is a basic esthetic principle. This may sound like heresy because one sanction of plain honesty in musical circles is to the effect that the performer must not garble the work of the composer; and, in training circles, we are rightly led to believe that true intonation in pitch and precision in temporal values as written are among the first skills that should be acquired. We may accept these as good training principles because the performer must be able to intone in true pitch and metronomic time with precision, before he can master the skills of artistic deviation from them.

Third, it is due to the recognition of the principle of artistic deviation that artists find unlimited opportunities for variation and interpretation, for the expression of their creative power and artistic sensitivity, and for differentiating their individuality as artists. While

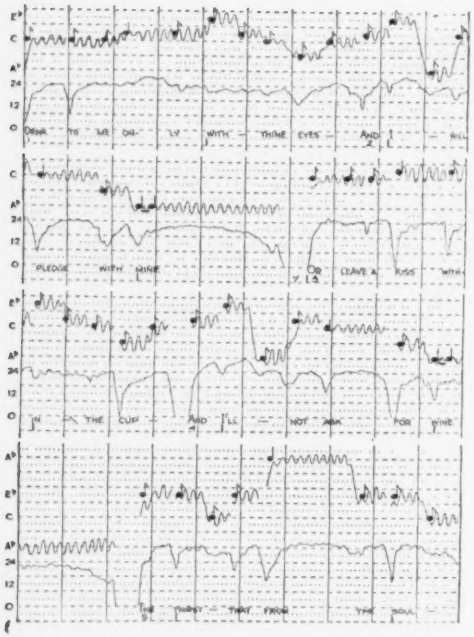


FIG. 1. DRINK TO ME ONLY WITH THINE EYES, AS SUNG BY ARTHUR KRAFT.
The dots mark off tenths of a second; the vertical bars, seconds. The horizontal lines separate semi-tones; the wavy line indicates the form of the attack and the release, the periodic pulsations, and progressive rise or fall in pitch. The lower curve shows the rise and progressive changes in intensity in terms of decibels. The musical notation is interpolated. From Seashore, H. G. An objective analysis of artistic singing, *Univ. Ia. Stud. Psychol. Mus.*, IV, 1937.

we assign first place in esthetic value to the composer's score, we are led to see that the artist must himself become a creator, or at any rate a molder, of the beautiful forms but crudely indicated in the score. Thus, while there is a definite area and responsibility for the student of esthetics in evaluating the score as a contribution of the composer, it is the artist's rendition which the scientist records and analyzes and which, in common language, is the music on which the listener bases esthetic judgment.

The Performance Score

The experimenter in musical esthetics now parallels the conventional musical notation with performance scores showing exactly how the artist rendered the design set out by the composer. This differs from the conventional notation in that it shows exactly how the artist used his musical media in creating the art object, the physical music. Instead of indicating a single note, such as a quarter-note, to specify pitch and time, it presents a graph showing the form of attack and release and the periodic and progressive changes in pitch: in short, all deviations from true pitch, whether artistic or erratic. It shows how the given quarter-note was modified in duration for the purpose of rhythmic phrasing or as a result of lack of skill. It likewise represents quantitatively in fine detail how this one note fluctuated in intensity. The three factors, pitch, time and intensity, are usually indicated in a single score, as in Fig. 1.

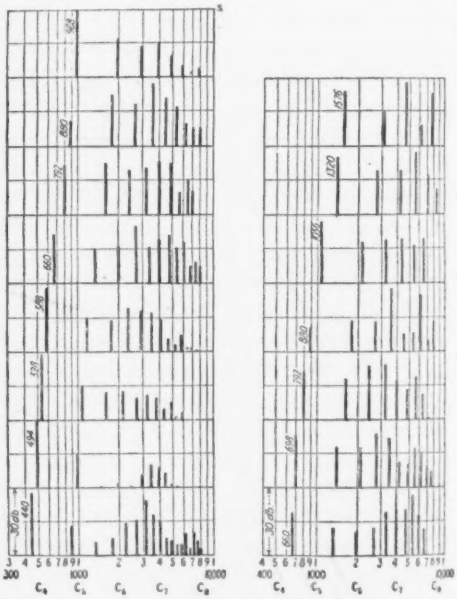


FIG. 2. VIOLIN ARPEGGIOS ON THE A-STRING, LEFT, AND THE E-STRING, RIGHT, AS PLAYED BY SMALL.
Vertical bars show the relative intensity of each partial in terms of decibels. Pitch is indicated at the bottom in terms of frequencies. Figures in italics indicate the fundamental pitch of each spectrum. From Small, A. The violin in the laboratory, *Proc. Mus. Teach. Nat. Assoc.*, 1938.

In view of the fact that tonal quality is in a constant flux in a tone, performance scores are presented in the form of simple cross sections of a given note, or series of notes, as fair samples in terms of a tonal spectrum, showing the harmonic structure of the clang, as in Fig. 2. Such a tonal spectrum is the basis for the hearing of timbre in a simultaneous fusion of the fundamental with its overtones. By showing the sequence of tonal spectra throughout the duration of the tone, we get a performance score in terms of sonance, as shown in Fig. 3. Thus we get a complete and objective description of the quality of tone as a whole.

Through such performance scores, we take the basic problems of esthetics from the ill-defined, intangible and airy regions of speculation, doubt and mysticism and reduce them to verifiable formulae on the basis of measurement. The invention of this simplified score is like the invention of a language; it enables us to transmit symbolically the result of countless observations and measurements in comparatively simple but scientifically indispensable graphs. These graphs may take a variety of forms depending upon the instruments used, the data in hand and the purposes to be served. The piano, for example, requires a special piano camera and a particular type of performance score, the principle of which is illustrated in Fig. 4.

For each of the basic aspects of music, we now have units of measurement and zero points of reference. Tonal modulations are measured in terms of the number of vibrations of deviation from the pitch of the note as indicated in the score; dynamic modulations are measured in terms of decibel deviation from the threshold of audibility or a standard reference tone; temporal modulations are measured as deviations from metronomic time in hundredths of a second;

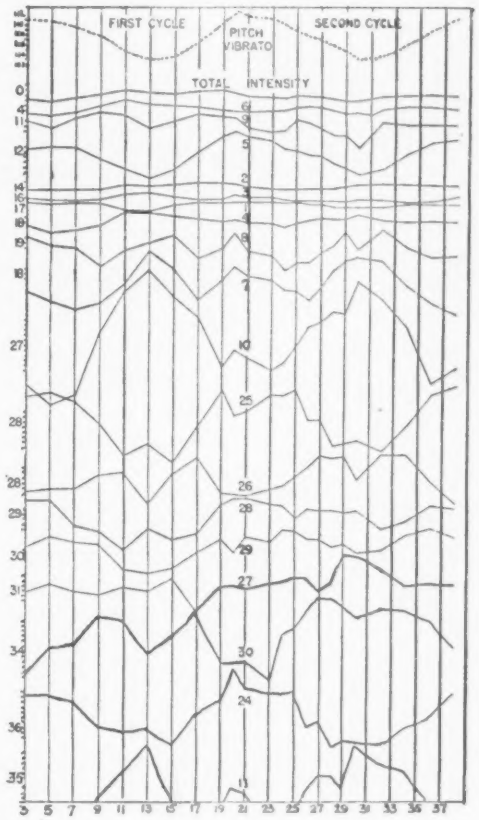


FIG. 3. THE INTERNAL STRUCTURE OF A BEAUTIFUL TONE AS SUNG BY BORCHERS, SHOWING SONANCE IN TERMS OF SPECTRA FOR ALTERNATE SOUND WAVES FOR A PERIOD OF ONE THIRD OF A SECOND.

Each vertical line represents a tonal spectrum for the line as indicated at the bottom. The intensity of each partial is represented by a horizontal graph numbered at the center. Numbers at the left indicate intensity levels in terms of the number of decibels below the total intensity, 0. Pitch is indicated by the small numbers at the left top. There are two cycles of pitch vibrato in this one third of a second as indicated in the top curve. It is assumed that each overtone has the same pitch vibrato as the fundamental. The timbre vibrato is revealed by the intensity pulsations of the partials, notably numbers 5, 10, 25, 30, 24. The even total intensity is the result of compensation in the partials. Observe that there are five partials that are stronger than the fundamental, the first partial. From the author's article on Sonance, *Mus. Ed. J.*, Oct., 1936.

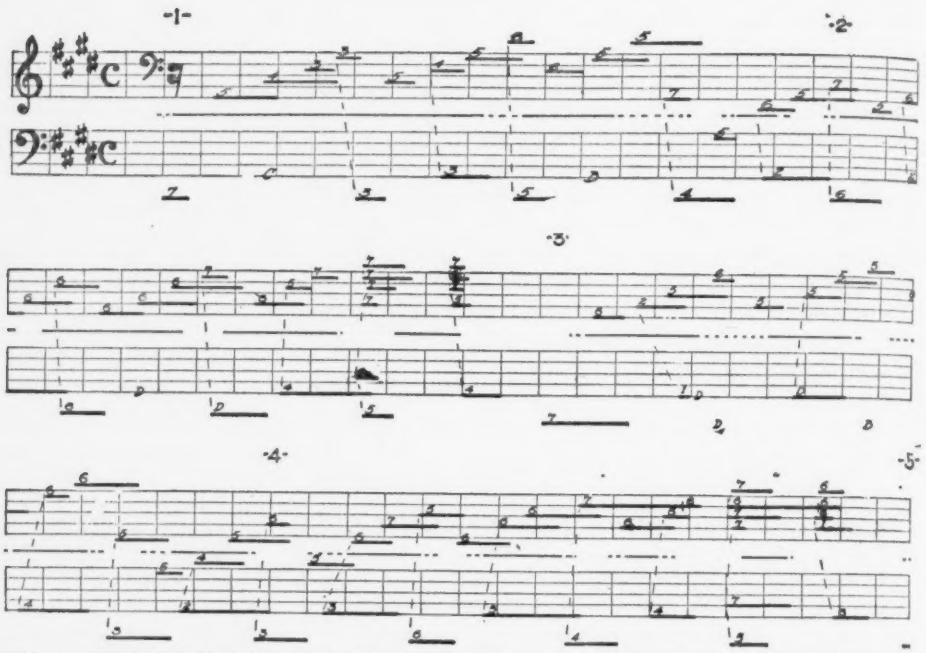



FIG. 4. THE FIRST FOUR MEASURES OF THE LAST MOVEMENT IN BEETHOVEN'S SONATA, OPUS 27, NO. 2, AS PLAYED BY CLAPP.

Each note is represented by a bar in the conventional cleff, showing the moment of incidence, the duration and the release of the note. The vertical bars mark off tenths of a second. The intensity is shown for each note by a number on the scale of 1 to 9 from the softest to the loudest (the intensity could be indicated on a decibel scale as in Fig. 1). Horizontal lines between the cleffs show the pedal action: solid line for full pedal; dotted line for "half" pedal; and break in the line for absence of pedal. The four measures are numbered. For description of camera and full performance score, see *Univ. Ia. Stud. Psychol. Mus.*, IV, 1937.

and qualitative modulations are measured in terms of redistribution of energy in the partials, the zero point of reference being the pure tone.

The idea I wish to convey is that acoustical science with its cameras has now intercepted the sound wave, which is the only and universal medium of music, and enables us to measure, analyze and present vast masses of facts in a simple and musically significant language. Thus if we want to know what artistic devices Lily Pons employs in singing, Menuhin in violin playing, or Hofmann in his piano interpretations, we may now invite them into the laboratory studio, where they will perform under the same conditions as for radio, and complete and permanent phonographic and photographic records will be available after a single performance. For many purposes the now available high fidelity phonographic recordings may also be used as research material, providing adequate precautions are taken in relation to the possible distortions. The phonophotographic record of the performance score will be the source material on which the future esthetician will work in discovering and verifying esthetic principles which operate in actual music.

The Principle of Deviation as a Medium of Musical Artistry

The point of view here presented is, of course, not new to leaders in the musical profession, but there is frequently a ten-

dency to underestimate or becloud the role that artistic deviation plays in music. Some critics proclaim that the types of detail shown in the performance score for actual musical artists are of little significance musically. We can trace several survivals of mystic tendencies and traditions in musical circles underlying this criticism in the absence of scientific information.

One criticism is that the musical performance is more than the physical sound. This "more" takes several forms depending upon the culture level of the musician, which makes it difficult for him to realize that everything that is conveyed from the performer to the listener, as music, is conveyed on sound waves in terms of which the performance score is built. He has some sort of mystic feeling that his own emotions, ideas of beauty, subjective interpretation or theories of musical values can be conveyed by some mysterious form of musical telepathy. When pressed for illustration he points vaguely to suggestion, gesture, association of ideas, smiles and frowns, environmental atmosphere and the supersensory reality of music. These may profoundly modify the perception, appreciation and interpretation of the physical tone, but they are not the music: the musical composition as actually rendered in physical tones is the only musical medium that can bridge the gap between the performer and the listener.

A more objective attitude is that of the musician who looks at the performance score and says that these minute deviations in pitch, loudness, duration and tonal quality are smaller than the ordinary errors of musical observation; the listener does not hear them. To this the experimenter replies that although they may not be heard individually, their mass and variety of forms combine to give character to the music which we do hear and judge, just as in a painting, a figment of red or blue may not be noticed by the observer, but the total accumulation of color figments in pigments and their infinite variety, blending and shading is what gives beauty in color to the picture.

A third objection comes from those who say that most of these deviations are simply errors in performance. That is, of course, largely true for many incompetents who ply the art, and it is also true of even the best artists in that their capacity for achievement is relative and that in many respects they assume a considerable region of tolerance for precision.

But in dealing with competent artists it is easy enough to find abundant material in the way of deviations which have esthetic value, even though they may not be heard individually as such. Frequently the performer himself is not aware of them because they function as well-established habits. Furthermore, the objective study of the performance score reveals the operation of a great variety of esthetic principles which spring directly out of the emotional demands without the performer's being aware of them as such. These are usually more numerous than the known or voluntarily followed principles.

This defense of the principle of artistic deviation from the beautiful is, of course, set up in contrast with the well-established esthetic principle assigning beauty to certain types of fidelity to the score. My contention is that the basic esthetic sanctions, such as unity and balance, harmony and richness, contrast and symmetry, are far more frequently obtained by principles of deviation than by principles of fidelity and uniformity.

Phrasing

With these preliminaries, we may now turn for illustration to some well-recognized principles of esthetics which can be quantified and systematized by the

experimental procedures here indicated. The most general term applying to principles of artistic deviation in practical music is that of phrasing. This is a very comprehensive term covering a vast array of esthetic principles, both subjective and objective, in musical artistry.

Fig. 5 shows how a violinist indulges in freedom from regularity. If he had not so indulged, the lines for pitch, intensity and time would have tended to be straight and would have indicated that the rendition was cold, unemotional and devoid of artistic interpretation. The student of musical esthetics must ask hundreds of questions in relation to a single passage like this. Assuming that the artist is competent so that the constellation of variations is significant, the student of esthetics must ask for every cross section of the score: Why did he augment or diminish the interval to this degree at this point? Why did he increase or decrease the loudness in this direction and to this degree at this point? Why did he take liberties with the metronomic time by lengthening or shortening, by anticipating or by overholding the note at this point? And if we had the timbre score in terms of the spectrum at each stage in the phrase, he would ask similar questions about it, and more of them.

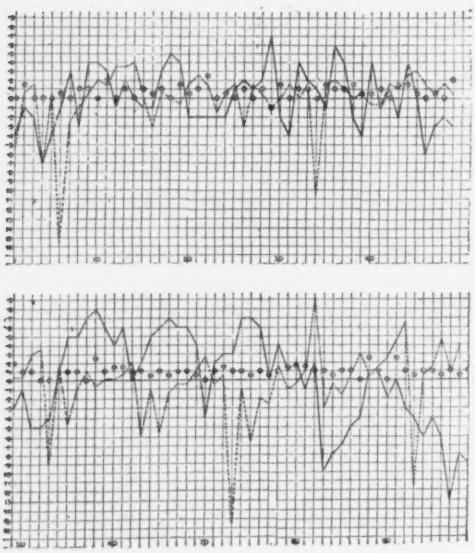


FIG. 5. SECTION OF PHRASING SCORE FOR PITCH, INTENSITY AND TIMBRE FOR THE AVE MARIA (SCHUBERT–WILHELMJ) AS PLAYED BY SLATKIN.

There is one point in the graph for each note as numbered at the bottom. Successive notes are shown on the abscissa. For pitch, units on the ordinate represent .1 tone, and the 0 point indicates exact intonation in the tempered scale. The circles mark the mean-pitch level of successive notes. For intensity, units on the ordinate represent 1 decibel and the 0 point indicates the average of the mean intensities of the notes. The solid line indicates the mean intensity for successive notes. For duration, units on the ordinate represent .1 seconds and the 0 point indicates exact distribution of time throughout a measure in accordance with the score. The dotted line indicates temporal over-holding (+), or under-holding (−) of successive notes. From Small, A. An objective analysis of artistic violin performance, *Univ. Ia. Stud. Psychol. Mus.*, IV, 1937.

The significance of this deviation is well illustrated when we attempt to compare two performers. For example, if we ask two equally competent professional pianists to perform a given beautiful selection at their best before the camera, the performance scores will reveal a remarkable similarity in their interpretative treatments of note, measure and phrase, although no mention was made of phrasing or the purpose of the recording. This indicates that there is a common stock of principles which competent artists tend to observe; that the character of each measure or phrase tends to make the same emotional appeal to both; and that they unquestionably find similar outlets for the expression of their individuality in the esthetic interpretation. We should not, of course, assume that there is only one way of phrasing a given selection, but even with such freedom, two artists will reveal many common principles of artistic deviation. Furthermore, in so far as there are consistent differences in their

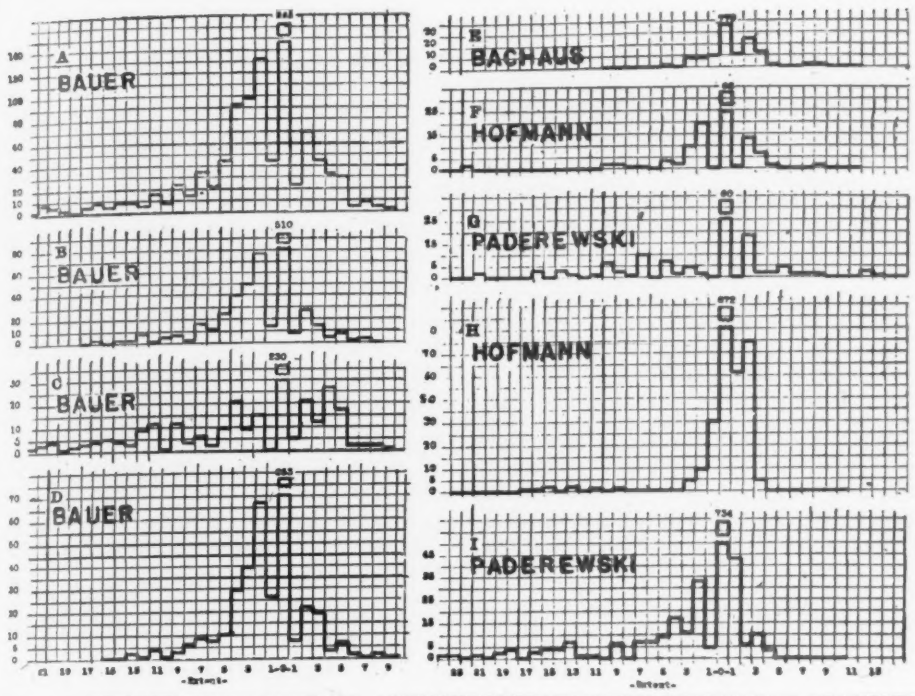


FIG. 6. EXAMPLES OF TYPICAL ASYNCHRONIZATION BY DIFFERENT PIANISTS IN TERMS OF FREQUENCY AND EXTENT OF ASYNCHRONIZATION.

Scale at the bottom .01 second; at the side, number of cases. From Vernon, L. N. Synchronization of chords in artistic piano music, *Univ. Ia. Stud. Psychol. Mus.*, IV, 1937.

phrasing, these differences may reveal elements of musical individuality.

Then again if we ask one artist to play the same selection several times in succession with no other instructions than to play as beautifully as he can, he will tend to indulge in the same artistic deviations in successive playings, provided he does not definitely aim to give different interpretations.

The asynchronization of chords by the advancing or delaying one hand as against the other or the leading note in one hand is one of the common devices for artistic effect in phrasing. This is shown in Fig. 4, by the slanting dotted lines. It has been shown that there are a number of varieties of principles of asynchronization which cooperate to the same effect; that significant asynchronization may occur as frequently as in half of the chords; that each type of music makes the characteristic demand for this device; and that each player may reveal his individuality in the use of this device both by the frequency and the extent of the deviation. Some comparisons of artists in this respect are given in Fig. 6.

One specific element in phrasing pertains to principles of diminishing or augmenting intervals in relation to accepted scales. Musical esthetics in the past has concerned itself with the interval, and to-day the fastidious violinist prides himself in his individuality and his skill in interval refinements, such as the augmenting or diminishing of an interval in various degrees for specific purposes. There are a number of rules which he recognizes, but ultimately his intonation is guided by a sort of moving feeling of fitness for each individual intonation. When we make objective measurements of the performance of the best recognized

violinists, we see that they all show certain common tendencies as to the direction, movement and extent of deviations from standard intervals; that none plays consistently in either the tempered scale or the natural scale; but that on the other hand there is a marked tendency toward the Pythagorean scale as shown by the condensed averages in Fig. 7.

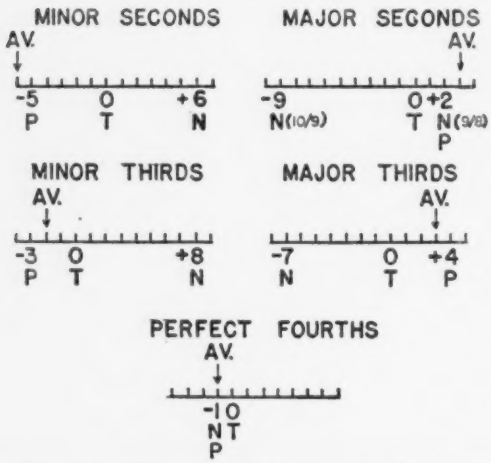


FIG. 7. THE AUGMENTING OR DIMINISHING OF INTERVALS BY VIOLINISTS.

The tempered scale is taken as a point of reference and marked 0. Plus indicates augmenting, minus, diminishing, of the interval. The scale is in terms of hundredths of a whole tone step. The theoretical position in this figure is marked by T for tempered, N for natural or just intonation, and P for Pythagorean. The average performance of six leading violinists is indicated by the arrow. From Greene, P. C. Violin performance with reference to tempered, natural and Pythagorean intonation, *Univ. Ia. Stud. Psychol. Mus.*, IV, 1937.

Let me but mention one more of the hundreds of varieties of esthetic principles that may be revealed systematically by a phrasing score; namely, the substitution of time for stress or stress for time which, in itself, becomes a complicated structure of theory and practice. From the early classical times to the present this has been a moot issue in poetry. But in music the issue becomes more evident and presents itself as a fascinating field for objective studies that may settle disputes which have raged for hundreds of years. In the best music we find abundant examples of the absence of stress in the accented note of the measure when the rhythm of the measure is very clear. We must therefore turn in search of a substitute, such as time for stress.

Some of these principles were known to the performer and served as a goal in his performance. The score can, of course, be used in verifying, elaborating and systematizing these. Other principles expressed with equal regularity were not known to the performer but are the result of the unanalyzed feeling of satisfaction in a particular deviation. We must, of course, always assume that there is a certain range of mere errors, but these can often be teased out by comparative studies.

Thus the phrasing score becomes a tool with which we can describe the artist's interpretation of a given measure, phrase or passage in terms of esthetic principles of deviation. In such terms we can set up esthetic goals for the acquisition of skills and emotional expressiveness. No one has yet made a complete analysis of a phrasing score or is likely to do so in the near future because it represents such an endless variety of artistic outlets; and yet we can at this stage take any esthetic principle recognized by a composer and trace it objectively in these scores, thus laying foundations for the classification of principles of artistic deviation, which is one element in the beauty or ugliness of music. We do not now know how many esthetic principles are involved, how they cooperate, interfere and integrate. But we do know that they are all expressed in terms of the possible variants in the sound wave: frequency, amplitude, duration and form. If we grant that the medium of music is physical sound, there is no escape from the principle that in terms of four variables of a sound wave

there is room for an infinite variety in artistic deviation and that it can be expressed quantitatively in a performance score.

These physical performance scores can be converted through the application of known laws of acoustics, physiology and psychology into what we may call hearing scores, showing what the listener actually hears, which is quite different from the performance score of the artist showing what he actually played or sang. This difference will, of course, vary with an endless variety of factors in the ability and application of the listener.

Musical Ornaments

As another general type of artistic deviation, let us turn to the field of musical ornaments. Of the thirty or forty recognized musical ornaments employed by artists but seldom indicated in the score, the vibrato is the most universal and musically significant type. It is one of the essentials of good musical quality and is present in the voice of every singer, young or old, trained or untrained, primitive or cultured, in long notes and short notes, in high notes, in low notes. Artists of instruments which allow fine modulation in pitch employ it deliberately; and even in some instruments, such as the woodwinds, it comes out automatically in good players.

Here we have a striking example of how a fundamental factor in performance consists entirely of artistic deviations from the regular. When we had taken this little understood, greatly abused and frequently misrepresented element into the musical laboratory we were able to list at one time more than two hundred musical questions about it which had been answered by exact measurement in the laboratory; such as, What is the vibrato? How many kinds of vibrato are there? What are some significant norms? What are its characteristic uses on the stage to-day? How does it compare in voice and instrument? Are so-called tremolos anything but bad vibratos? What are some of the common elements of vibrato and the trill? What illusions of hearing make it tolerable? What is the average pulsation in the pitch vibrato? In the intensity vibrato? In the timbre vibrato? Why is the vibrato so often objectionable? What factors determine tolerance in rate? How can we refine the vibrato on the basis of experiment? It sounds a little like magic to assert that questions of this kind can be answered by the hundreds by taking adequate samples of performance into the laboratory and making exact measurements and analyses; but such measurements are now a matter of routine.

We may define a good vibrato as *a pulsation of pitch, usually accompanied by synchronous pulsations of loudness and timbre, of such extent and rate as to give a pleasing flexibility, tenderness and richness of tone,* and we may define a bad vibrato as *any periodic pulsation of pitch, loudness or timbre, which singly or in combination, fails to produce pleasing flexibility, tenderness and richness of tone.* These definitions imply that there are three species; namely, the pitch vibrato, the intensity vibrato and the timbre vibrato. And of each of these there is a wide array of varieties, each contributing in some specific way to the beauty of tone. There is an enormous leap from the bare recognition of the existence of the vibrato, or the denial of it in many a musician, to such complete exposure of its reality, its roles, its limitations, its objectively verifiable definition and description as they emerge from the laboratory.

The laboratory has two fundamental approaches. First, the natural history method by which a sufficient number of fair samples are collected from their true settings in beautiful music and then measured, analyzed and classified. The

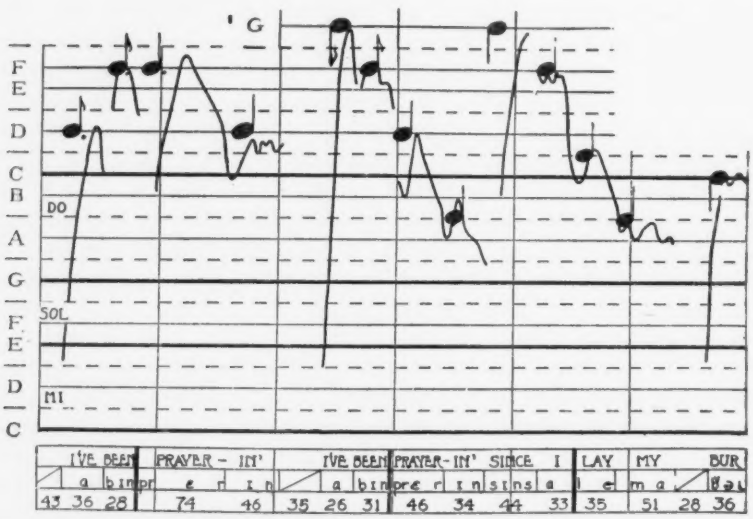


FIG. 8. PERFORMANCE SCORE OF AN UNTUTORED NEGRO SINGING A SPIRITUAL BEAUTIFULLY IN A CORN FIELD OF NORTH CAROLINA.
For notation, see Fig. 1. From Metfessel, M. J. Phonophotography in Folk Music, Univ. North Carolina Press, 1928.

other is the method of physical science in which with the use of tone generators we can produce any desired form of vibrato experimentally to verify known esthetic principles and discover new ones.

One need hardly mention how a specific scientific knowledge of the vibrato increases the resourcefulness in the hearing of it. How different is the critical hearing of the vibrato in the actual musical situation by one who has been trained in the laboratory or the studio to hear its countless manifestations, from one who recognizes an undefined change in tonal quality!

Musical License

Until recently musical anthropologists described primitive music, such as that of the Indians or the South Sea Islanders, in terms of our conventional scales, simply mentioning that certain types of freedom or "errors" were exhibited. But when phonophotography came in, the ridiculousness of that attempt was made manifest. Fig. 8 is an illustration of a Negro singing a spiritual very beautifully. I have interpolated the musical notation which indicates what we tend to hear. But the performance score shows how far this is from reality. We listen to this untutored Negro's beautiful singing in terms of our habitually established interval scales. It would be foolhardy to say that this song was not good because he did not have true intonation in terms of our musical intervals. Thinking only in terms of pitch, we might say there is an esthetic principle, which we might call the principle of soaring, with complete pitch license, like the eagle winging its way in graceful sweep. It is interesting to observe how this Negro superimposed a pitch vibrato upon the actual pitch line in the performance score instead of upon the intonation of a true note in the scale. This principle of soaring, then, instead of being regarded as a departure from true music, represents a principle of beauty in itself, a form of artistic license, the eating of forbidden fruit, the spontaneous expression of feeling.

This principle of soaring is, of course, present in infinite variety, such as that of attack and portamento and other forms of glides, in ornaments and in gradual transitions from speech to musical intonations.

Nature of the Esthetic in Music

In the above I have shown how the scientist takes the actual music of the composer and performer and dissects it in the laboratory for the purpose of description, classification and explanation of the phenomena involved. We have found reason to demand that a fundamental requirement of the artist is the ability to intone in true pitch and metronomic time. True pitch, metronomic time, pure tone and even intensity represent fundamental esthetic values. But while beautiful in themselves, they represent mainly points of reference for orientation from which artistic deviation constitutes the main groundwork of musical artistry.

At this stage we may well inquire what the phenomena here discussed have to do with esthetics. Many good musicians have not read any books on esthetics. Academically the subject is usually taught as a branch of philosophy just as was the subject of psychology half a century ago. But as psychology has now been taken into the laboratory and has been recognized in the sisterhood of sciences, so many problems of esthetics are now taken into the laboratory, and wherever possible, scientific experiment is substituted for artistic speculation.

There is still room for a number of distinctive and legitimate approaches to the subject. The philosopher analyzes the concept of musical values, the theory of knowing esthetic values and the nature of beauty in relation to ultimate reality. Sometimes he is in danger of imposing a mystic or esoteric conception of the nature of the beautiful. The musical historian and critic traces the evolution of musical concepts of beauty in terms of the progressive enrichment of musical composition and musical performance by the adoption of new media. The anthropologist traces in a similar way the evolution of the progressive development of music in races and nations. The artist formulates esthetic rules of performance and embodies these in artistic skills. The educator aims to increase the power of the appreciation of music and the development of musical skills in the light of available knowledge.

All these approaches nibble at the question: What is beautiful in music and how can we know it? One seeks universal principles, another seeks practical rules, another traces the evolution of this human power of exhibiting the beautiful, another aims to enlarge our knowledge and deepen our appreciation of it; and the latest comer, the scientist, comes in and offers to describe, criticize, verify and explain wherever scientific procedure is possible.

THE EVOLUTION OF WAR

By ARTHUR STANLEY RIGGS
WASHINGTON, D. C.

WARFARE, instead of being the mark of an inferior and uncultured type of man, has from its inception been the product —on the aggressor's part—of the most advanced civilization. Necessarily, then, we must somewhat recast our ideas of it, of the evolution which swung it forward from clumsy mass murder and rapine without interest or any redeeming feature to its present form, horribly multiplied at times, but rendered intensely interesting as a social study because of its psychology, strategy and tactics.

Before we go any further we must agree upon a definition of what we are considering. To be both clear and convincing, that definition must include a great deal more than the shock of armies or fleets meeting in action.

"War," said General Baron von Clausewitz, one of the world's greatest military analysts and historians, is "only a continuation of State policy by other means . . . none of the principal plans which are required for a war can be made without an insight into the political relations." And again: ". . . war is not merely a political act, but also a real political instrument, a continuation of political commerce, a carrying out of the same by other means . . . for the political view is the object, war is the means, and the means must always include the object in our conception. . . . State policy is the womb in which war is developed."

To this we may add the statement by General Sir J. F. C. Fuller, D.S.O., formerly of the British Imperial General Staff: "Though . . . the establishment of a more contented, prosperous and secure state of peacefulness is the true grand strategical object of a war, it by no means follows that this has been generally accepted; in fact, few wars have led to so desirable a conclusion."

It should be obvious from these two statements that war was a phase of life unknown to primitive man. Eolithic man, and his successors for thousands of years, had nothing worth fighting for, material or otherwise. Not until his club and hand-stone had developed from crude domestic tools into offensive weapons, and he possessed women and other animals capable of bringing him increase, did he become a property owner, thus exciting the envy of his fellows. With the passage of a few more thousand years he became civilized enough to abandon nomadic life, to herd with his fellows in large groups, and eventually to build towns.

By this time he possessed considerable rudimentary culture. He had the beginnings of agriculture, of architecture, of pottery; he had probably even learned to use fire and to make clothes of some sort. His substantial mud-brick or stone and wood hut was something to be proud of. His possessive instinct waxed strong and bold. He looked around, saw that other towns had better houses, larger herds or flocks, perhaps more desirable women. Envy bred cupidity; cupidity easily transformed itself into mass raiding. Danger spiced the enterprise, and the loot satisfied his savage longings.

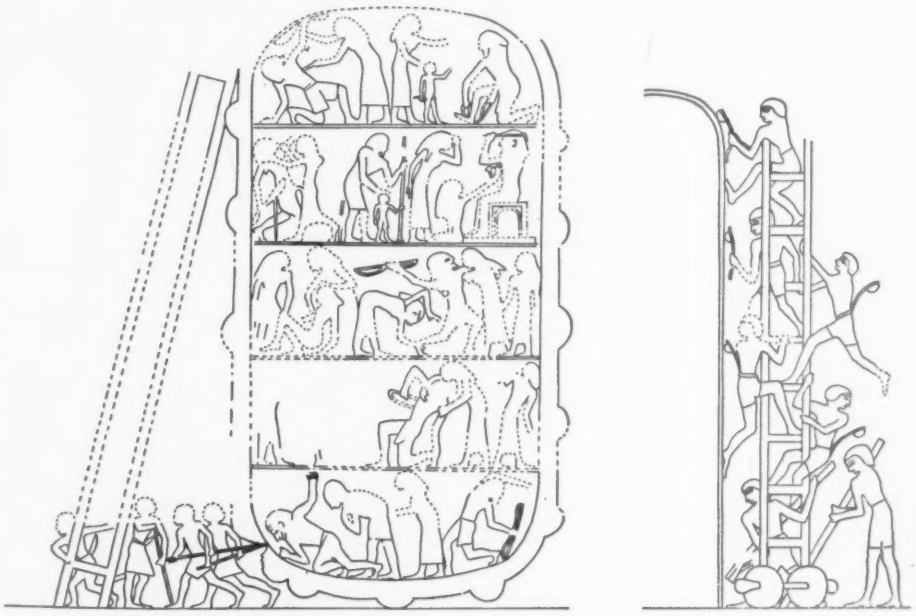
This, however, was no more true war than are the violent predations of gangsters in our modern cities. It was the beginning of the everlasting struggle between the "Haves" and the "Have-Nots." It was marauding only; it went

on as marauding for no one knows how many millennia; it goes on to-day among still primitive tribes.

With the increase of both wealth and culture, time eventually produced strong tribal and community leaders, the loose grouping of early society gave place to a more orderly civilization, and we have the beginning of kings. These petty monarchs, if judged by our standards, were probably the biggest and strongest thugs in their respective groups. They had to be physical masters to hold control. As power feeds upon itself and grows accordingly, it was not long—archeologically speaking—before these little kings precipitated a substantial body of folklore, developed a cult of royalty, formulated genuine government and even created something in the nature of royal policy.

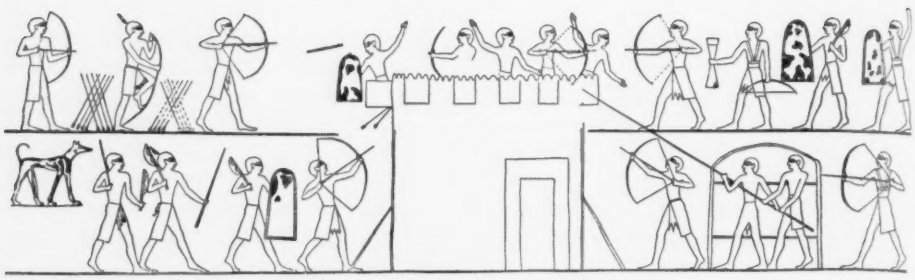
War began somewhere in the dim past when one of these early kings decided that it was not good for his town and region to have a potentially inimical city-kingdom only a day's march or so away. To persuade his councilors, and then the rabble, of the necessity of wiping out their neighbors was easy. Just where that first war started no one knows. The minor kingdoms of ancient times left little to record their valor. So it is not until we reach Egypt in point of time that we find the martial phase of politics not only well developed but recorded in astonishing detail.

Before 4000 B.C. Egypt was fighting as a matter of state policy, by orderly means, against raids and encroachments of jealous enemies. For the first time we see war conducted on the basis of its three indispensables: movement, supply, destruction. For the first time, also, we find during the fifteenth century B.C. a definite understanding on the part of an Egyptian general of both strategy and tactics. Strategy, not to be too technical, might be loosely defined as the art of war; tactics as the scientific application of that art.



WALL-PAINTING OF ANCIENTS ATTACKING A FORTRESS

FORTRESS REPRESENTED BY GROUND PLAN SHOWING BUTTRESSED WALL INSIDE OF WHICH A CONFLICT IS PICTURED IN FIVE REGISTERS. EGYPTIAN WOMEN ARE SHOWN DEFENDING THEMSELVES AGAINST FOREIGN INVADERS. FROM A LADDER ON WHEELS BESIEGERS TRY TO BREAK DOWN WALLS.



SOLDIERS ATTACKING A FORTRESS

FROM A WALL-PAINTING IN THE TOMB OF AMENEMHAT AT BENI HASAN, ABOUT 1940 B.C. THE ATTACKING PARTY WITH BATTLE-AXES, SOME OF THEM PROTECTED BY SHIELDS OF DAPPLED BULLOCK'S HIDE, MAKES AN APPROACH TO THE FORTRESS GATE UNDER COVER OF THE ARROWS OF THEIR ARCHERS, WHILE MISSILES ARE HURLED DOWN ON THEM FROM THE BATTLEMENTS. IN THE UPPER ROW, AT LEFT, AN ARCHER IS STRINGING HIS BOW BY PRESSING HIS KNEE AGAINST INNER SIDE; IN THE LOWER ROW, AT RIGHT TWO MEN SHELTERED BY A TESTUDO TRY TO SPEAR DEFENDERS ON THE WALL WITH A LONG PIKE.

At this relatively recent period war had not developed. It was a matter largely of frontal mass shock and a free-for-all mêlée without regard for the waste involved. The labored dullness of the military type of mind which was responsible for this has continued unchanged from prehistory to the present. Basically it works in exactly the same way as the mind of the primitive who had only clubs and stones as weapons. Consider, for example, the ruthless feeding of Italian peasants who do not want to fight into the direct fire of Greek guns in Albania; or go back to the last World War and remember the way Crown Prince Wilhelm forced his men into the horrors of Verdun, until almost six hundred thousand of them rotted about the French fortifications.

By the time the Feudal Age had reached its perfection, the Egyptians had learned to link warlike purposes with economic advantage. About 2000 B.C. they did one of the most remarkable things ancient history records. They dug the first Suez canal. It connected the northwestern horn of the Red Sea with the eastern branch of the Nile. Freight and passenger boats could thus come from Punt (the present Somali Coast) with their precious loads to Egyptian distributing points. Commerce leaped forward—and Egyptian war galleys could by means of this short cut transport armies and supplies to strategic points without delay or difficulty. The link went even farther, for the products of distant Crete and perhaps even Sicily became available to the dwellers along the Red Sea and Indian Ocean, while the redoubtable Egyptian Navy began to make its power felt throughout the Mediterranean.

By 1580 B.C., when Ahmose I came to the throne, he found an Egypt with a first-class professional army also, having expert archers as the dreaded mainstay and fire power of its offense. These highly skilled infantrymen had learned how to fire by volley with such effect that they established a reputation which made them feared a thousand years. Moreover, besides their bows, they carried spears for short-range work and battle-axes for hand-to-hand combat. As a tactical unit, a battalion of these archer-spearmen compares perfectly with a battalion of modern infantry equipped with rifle and machine-gun for long range, hand-grenades for close, and the bayonet for hand-to-hand work.

It was under the generalship of that old lion, King Thutmose III, in 1479 B.C.,

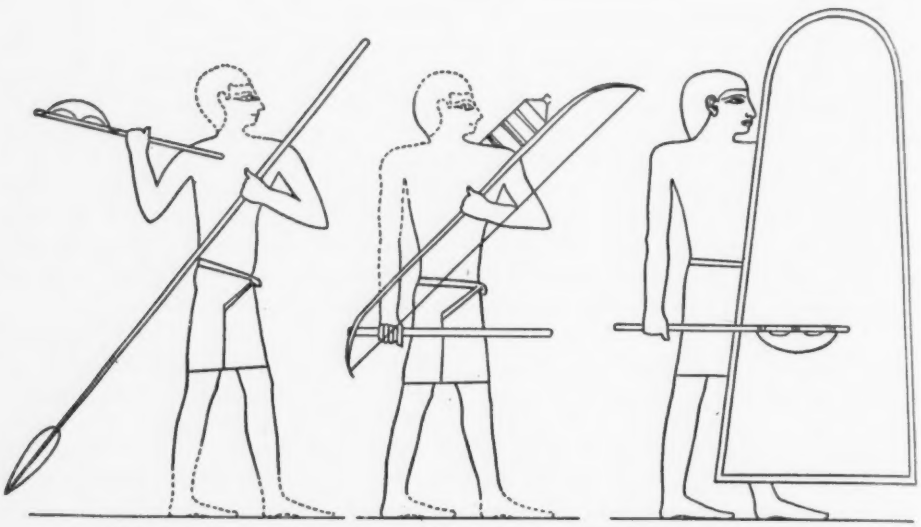
that Egypt demonstrated to the world that she had—at least in the person of the king—the essentials of strategy. On the morning of the 15th of May he had disposed his army in such a manner as to prevent the flight of the King of Kadesh, trapped with his army before the city of of Megiddo. Satisfied that all roads to the north were effectively blocked, Thutmose got into his glittering chariot of electrum and led a roaring charge against the enemy. They broke at the shock of the galloping horses and heavy chariots, fleeing in every direction. The fight became a rout, and everything was abandoned on the field. The strategic plan of battle was perfect. Tactically there was nothing left to be desired. But the plans failed because Thutmose had not realized that his soldiers would forget all about duty in their frenzied looting. In the confusion the King of Kadesh got away and the job had to be done all over.

Thutmose's strategy, however, does not imply that military campaigns took such subtleties into account generally in the world of that day. Human thinking had not yet advanced to the point at which such a thing was possible. Politically Egypt was both shrewd and unscrupulous, and the detailed story of her foreign policy reads like a twentieth century European chronicle of the growth of population, the gradual raising of internal pressures, the ambitions of the king's political advisers, the forcing of external commerce followed by the necessary establishment of colonies to foster and maintain it, then the dispatch of troops to protect the colonies, the familiar frontier incidents, the cry of the greedy for more room and more power and war.

At this point we note a vital difference between the raids of preceding times and the organized warfare of the Egyptians. The former was total, and left the defeated country stripped bare of all useful life as well as of everything worth stealing. Egyptian conquest cost the defeated dearly, but no Egyptian general or king ever stained his record with unnecessary slaughter, slavery or theft. When Megiddo fell, besides all the booty of the actual battlefield, the city had to pay tribute, of course, but there was no such brigandage as the Germans to-day are exercising in Norway and Holland. Slaves were taken in war, of course, and many of them were horribly abused in the mines far to the south; but the general policy of exacting penalties only drastic enough to make the conquered people behave tied in with the advanced

MILITARY ESCORT OF A KING IN THE EMPIRE

FROM WALL-PAINTINGS IN THE TOMBS OF MERYRA AND AHMES AT TELL AMARNA, DATED ABOUT 1375–1358 B.C. (1) EGYPTIAN SPEARMAN ARMED WITH SPEAR AND SQUARE-HEADED BATTLE-AXE, WITH A SHIELD FOR DEFENSE, (2) THREE FOREIGN SOLDIERS REPRESENTATIVE OF MERCENARIES IN THE ARMY: LIBYAN WITH BATTLE-AXE, SEMITIC SPEARMAN AND NEGRO BOWMAN, (3) TRUMPETER.



ARMED ATTENDANTS TO A NOMARCH OF THE MIDDLE KINGDOM

FROM WALL-PAINTINGS IN THE TOMB OF TEHUTIHOTEP AT EL BERSHEH, DATED ABOUT 2000–1788 B.C. SERVANTS ARMED (1) WITH SPEAR AND BATTLE-AXE, (2) WITH BOW, QUIVER AND SHORT STAFF, (3) WITH BATTLE-AXE AND GREAT SHIELD.

levels of art, science and religion which characterized the Nile dwellers.

The point already made, that strategy was not widely understood, was also characteristic. The king might on rare occasions prove a strategist, as Thutmose III did. But usually he was a mere theocrat, a politician, an egoist and, if he happened to be personally courageous, reckless in his impetuosity. He was also severely handicapped by having too many generals who were politicians and ambitious for their own advancement, but who knew little of the real art of war. Because of the experience gained in the long struggle to expel the Hyksos usurper dynasty, tactics had made a considerable advance, and we have besides the much feared archer in the infantry, the precursor of cavalry, the chariot corps. In action, the chariots charged with a fearful yell while the archers fired a blinding volley over their heads and charged at the double for close work after the horses and vehicles had broken the enemy line.

Up to this time the horse had not yet begun to figure as the vital element in shock tactics. If the enemy line happened to be many files deep, the chariot charge would itself founder in the first few ranks, and the army reform to meet the oncoming archer-spearmen undismayed. It was all very much on the order of a first-class riot.

During these early times naval power was little understood, was correspondingly not used in any strategic manner, bore little relation to or coordination with the armies, and so failed to accomplish what it otherwise might have done. The Egyptians, again, were the only seafarers who made statesmanlike use of their fleets. The Minoans of Crete had gone as far west as Sicily, and perhaps conquered it in a raid; but they quickly passed and left nothing permanent. The Egyptians, some hundreds of years later, captured one Mediterranean island after another, followed up their naval conquests by colonization and military occupation, and had some glimmerings of the true purpose and effectiveness of sea power, though naval strategy was still

undreamed of and far in the future. This universal misconception and neglect of sea power accounts for the fact that national policies until within the most recent times have been based almost wholly upon military power alone. To-day we realize that wars are primarily economic in their generation, and that to be successfully prosecuted there must be a fusion of all interests and arms. But that is so modern a conception it was not fully grasped even during the first World War and is not understood to-day by a majority of the people anywhere.

In marked contrast to the humane behavior of the Egyptians at war was the Assyrian method. Here was a fierce mountain folk, weaned upon the blood of its enemies, making a national policy not only of unprovoked wars of conquest, but using the most revolting cruelties in prosecuting them. That the Assyrians knew something of the use of fear as a psychological weapon to demoralize the enemy before the shock of battle came is well established. This was strategy of a sort; but in the field the Assyrians evolved no startlingly new conceptions. Like the Egyptians, they relied, at least in the early stages of their development, upon their archers. Later they developed true cavalry battalions, which gave them vastly greater speed and mobility than any of their rivals. The unimpeded horse could outpace the chariot at its best, and was particularly useful in mountain work where the heavy vehicle could not go at all.

Not even the most careful apologist for this astonishing race can escape from the categorical records they left behind in shameless approval of their conduct. Cut off from access to the sea and its trade by the Mitanni and the Phoenicians to the northwest and by the Egyptians to the southwest, the Assyrians, like the Germans of to-day, developed from a small group of no importance to a flourishing nation which, during its great empire period, between about 750 and 612 B.C., carried on trade widely, conducted ruthless total warfare, developed an astonishing civilization peculiar to itself, and lived merely to die in the field. Before its day of splendor ended, it had conquered and wiped out ancient Babylon, captured and ruled Egypt with savage harshness, extended its sway far up beyond its own borders into the mountains, turned Palestine into a mere tributary, and burned the stamp of its terror into the souls of every nation even remotely bordering it. The taint of the wild beast was in Assyrian blood.

Courtesy American Museum of Natural History

MURAL OF NEOLITHIC MAN IN THE CAMPIGNIAN STAGE OF DEVELOPMENT

NOTE CONICAL HUT, COOKING POT AND DOMESTICATED DOGS. PAINTING BY CHARLES R. KNIGHT.

Byron knew it when he sang that "The Assyrian came down like the wolf on the fold." Wherever he went he left annihilation or smoking desolation behind. Upon the gates of what had been prosperous cities were nailed the hides of prisoners of importance, skinned alive and flung to the dogs, while the horrified populace stared with incredulous eyes at the bloody work the snarling curs finished. About the gateways, to add terror, tall stakes driven into the earth supported the writhen corpses of kings and generals, impaled shrieking as an object lesson. Total war was resuscitated, made more ghastly. The modern German is merely an imitator of his classic predecessor. Frightfulness was the code the Hun took over from the Assyrian.

IRON DAGGER BLADE
WITH ENGRAVED DESIGNS. FROM THE LASITHI PLAIN, GREECE. ABOUT 1800–1600 B.C.

The analogy between Assyrian and German may be carried still farther. While the Assyrian system of calculated savagery was reducing country after country and rapidly extending the Assyrian boundaries, the empire was paying a price so terrible that the greater the successes achieved, the deadlier were the germs of doom loosed upon the country. Conquest meant fighting, and even the redoubtable Assyrian army had to sustain a good deal of blood-letting. Frantic enemies fought for their lives and killed so many Assyrians that eventually the army consisted to a large degree of foreign levies and slaves. Centuries before it had been necessary to conscript the peasantry from its fields for only short periods. The losses had not been insupportable. But steady campaigning and the growth of the army to meet the needs of the occasion, hold the new borders and go on to further conquests, finally all but wiped out the peasants. Great and small farms lay fallow because there was no one to cultivate them. The food supply dwindled; famine threatened; not all the supplies from the outside made good the deficiency. Rich profiteers bought up the desolate farmlands and created showy country estates. But these produced nothing of value. Forced labor was not sufficient to supply the army, and the rest of the population fared ill indeed. Hunger, worry and fear stalked the land.

Then the blight extended from the home territory into the conquered lands. The Assyrian monarchs, though they introduced the cotton tree and made a feeble effort to create a new industry, failed completely to see that their national policy was as destructive as their system of warfare. Revolts sprang up everywhere. The subject countries—one thinks inevitably of Austria and Czecho-Slovakia—were full of sedition and bitterness, their levies in the army could not be trusted in hard fighting, and on every hand those enemies not yet stifled

threatened the rapidly weakening empire. Assyria at last had *Lebensraum*—room to live—so much room that its armies could not support themselves or defend their boundaries. In 612 B.C. the once invincible Assyrian army went down, after the Persians' two-year siege of Nineveh, into such a total defeat that the city was laid flat, the people annihilated, their language wiped out of human memory. Nineveh was nothing more than a vague tradition, and a series of astonishing clay-tablet records which shamelessly boast of the Führers of the period and the severity of their military methods. Total war had found its reward in its own extinction.

Two things are evident thus far. First, war as a national enterprise conducted under orderly methods is clearly the extension of economic and political necessities, or what were considered necessities. That was what distinguished war from marauding. Second, we see war still as a matter of frontal attack and the effects produced by shock. The occasional strategy of a genius like Thutmose III makes the contrast the more glaring. Since Assyrian times war had not developed at all in frightfulness and relatively little in methods. History has repeated itself again and again until we find the growth of numbers so enormously swollen by 1914–18 that weight paralyzed mobility, and war settled down to trench murder.

Between these two periods, however, strategy and tactics revealed themselves startlingly from time to time in unanticipated ways. The Assyrians had shown the world that cavalry was more mobile, swifter and more flexible than chariotry. It was the classic Greeks who, next after the Egyptians, resorted to strategy of the highest character when they built and successfully used the wooden horse. Homer sang immortally the triumph of both ruse and tactical device.

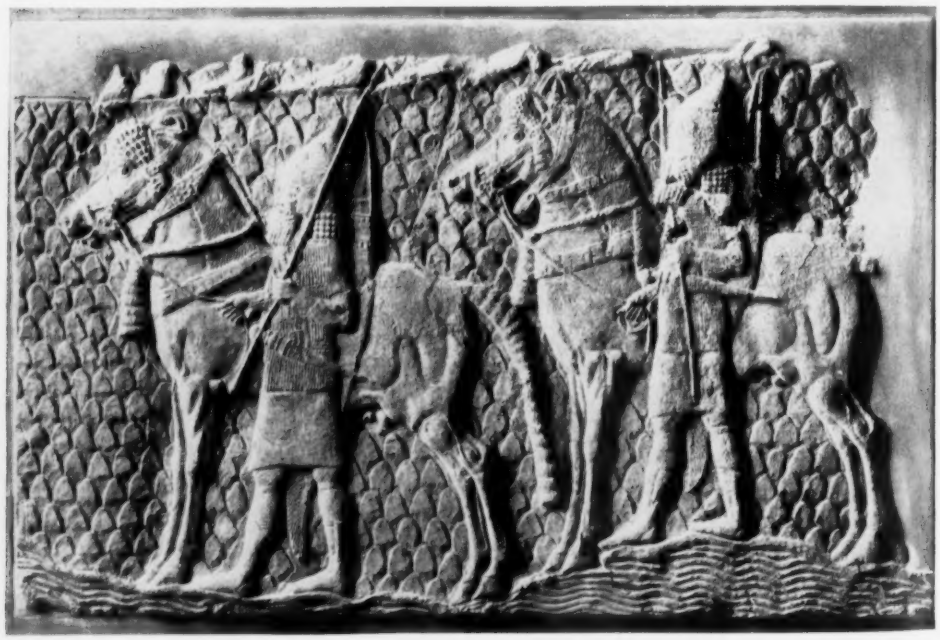
The Greeks, nevertheless, did not always distinguish themselves strategically. If we may credit the accounts we have of Greek battles and the hero tales of the Golden Age and earlier, we have to admit that war to the Greeks was a sort of super-badboy affair except where it concerned the repulsion of an invader. There the heroism and brilliance we have witnessed to-day in Albania had their vivid inception. Here and there, of course, some individual leader was thinker enough to introduce a new idea into war, turning the old roaring shock into something entirely different.

After the fall of Nineveh and the coming upon the scene of the Persians, there began a shrewd national policy which led later to the collision with Greece. Centuries before, the Egyptian canal at Suez had silted up and been forgotten. But Darius the Great in 521 B.C. looked far ahead with statesmanlike keenness and foresaw the time when Persia would need ships and sea fighters desperately to protect the conquests of which he dreamed in a very practical manner. So he explored the Indus River, the coast from its mouth to Suez, discovered and reconstructed the old canal, built a war fleet and sent it by this short cut far up into the Mediterranean Sea. After that he organized a powerful Phoenician auxiliary fleet, and Persia became the first great sea power of Asia. Before Darius died the Persian western frontier was the River Danube.

It was inevitable, therefore, that Persia should attempt to spread toward the south under Darius's son, Xerxes, and the head-on crash with little Greece became certain. Gathering the mightiest armada ever seen, Xerxes moved ponderously to the attack, the quarrelsome Greek city-states united for mutual safety under the leadership of Athens, and the first and mightiest shock came at Salamis in 480 B.C. To meet the combined Phoenician and Persian fleets Greece was able to gather only an in-

Courtesy of the Metropolitan Museum of Art

DETAIL OF SHEATH FOR SCYTHIAN SWORD, FIFTH TO FOURTH CENTURY B.C.
SHOWING A GREEK FIGHTING A PERSIAN.



SLAB FROM A WALL ALABASTER FROM SENNACHERIB'S PALACE, 705–680 B.C.
SHOWING KING SENNACHERIB'S CAVALRY IN THE MOUNTAINS.

ferior force, and Themistocles, the Athenian commander-in-chief, was afraid his allies would run away if the battle began to go against them. His strategy, therefore, was based primarily upon the fear of his own weakness, but it was none the less brilliant.

Instead of meeting the Persians in the open sea, Themistocles took his heterogeneous fleet into the bay on the island of Salamis, close to the mainland. This bay has two entrances, a small mouth to the west, a large one to the south. The moment Xerxes' admiral saw what the Athenian had done, he was convinced that the Greeks had made one of those fundamental blunders which can not be retrieved. Ordering his Phoenician allies to close the western entrance and cut off any Greek retreat, the overconfident Persian moved with his main body to attack through the large mouth. The Greeks were bottled up securely. They had to fight because they could not run away. Themistocles' strategy was justified by the disastrous defeat of the Persians.

BRONZE SWORD MADE FOR KING OF ASSYRIA, XIV CENTURY B.C.

A century later, in 371 B.C., another brilliant example of strategy illuminated the dreary chronicle of Greek civil warfare. At Leuctra, Thebes and Sparta met in desperate combat. Epaminondas, the Theban commander, like his Athenian predecessor, knew his troops were low in morale. Armies fought in an extended line, the best troops and bravest individuals, as well as the commander himself, holding the right. The weak spot was generally the left wing. Epaminondas scouted his enemy, saw that Cleombrotus, the Spartan king, had his best men twelve files deep in his right wing, and accordingly made his own left the heaviest shock body ever known to that time—fifty files deep, in phalanx, with the famous Sacred Band in front. Then, in furtherance of his idea, and to render the shock more paralyzing, he arranged his entire force *en échelon*, and moved obliquely to the assault, first instructing his center and right to delay attack until he had broken the Spartan front. Spartan courage has never been impugned, but the heaviest shock the Spartans had ever known was multiplied by the surprise of the Thebans' new methods. King Cleombrotus fell at the first exchange. About him died most of his staff. The weight of the Theban phalanx crashed through and tore the Spartan line to tatters. Men had begun to learn.

Again strategy and tactics forged ahead when Alexander of Macedon reversed the usual idea of mass fighting and of the elements that made up armies. First he did away with the slightly trained citizen-soldier as the main striking power of all armies, replacing him with disciplined professional soldiers. Alexander also perceived that if a good soldier was effective, a good soldier mounted upon a good horse would be many times as effective in striking power; and since mass assault was still the keynote of battle, he kept his infantry to the rear, put his ablest men on

CHARIOT OF YUYA AND TJUYII,
XVIII EGYPTIAN DYNASTY.

horseback, and won every one of his great battles by thundering charges that no phalanx of the time could resist. He invented the new tactical unit of heavy cavalry, and put it to successful strategic use.

After the Greek examples of occasional spurts of progress, war slipped back again into its familiar rut of clumsy murder. The Romans reverted completely to type in adopting the legion as their standard of armed force. True, the legion, armed with short, heavy sword and short javelin, and professionalized to the last degree, conquered the world. But it was a bloody, smashing, brutal affair for the most part. Very few of the Roman consuls and other leaders were soldiers. The Roman armies often suffered from being led by politicians; even at times from having three political leaders (consuls) simultaneously, each one exercising command a day at a time.

Politics were the ruling factor in Roman life when the greatest strategist the world had known appeared in Italy in 217 B.C. Not yet thirty years old, Hannibal of Carthage performed the incredible feat of marching his entire army, elephants and all, across the Alps in the dead of winter. Rome did little to stop him until he reached the relatively easy plateau of northern Italy. Fabius, the Roman general who awaited him in the plains, was a soldier and a good tactician. Before Hannibal's advance he dropped back steadily until he had reached the shores of Lake Thrasymene. Then, through political changes at Rome, he was recalled. Without his wise leadership the Romans had to trust to the senior consul, Flaminius, who blundered into a trap set by one of the keenest strategists of all time.

During the night Hannibal so placed his troops that a large part was hidden in the narrow gulches between Thrasymene and the Cortona mountains, his main body being camped on a rise in full view of the Romans. Failing to reconnoiter his road, Flaminius marched confidently into the gulch at dawn, not seeing the troops above and to either side of him, and charged down upon the Carthaginians massed in front. Silently the ambuscade closed in behind him. What followed was sheer massacre: at least 15,000 Roman legionaries killed, thousands more wounded, and ten to twelve thousand stragglers driven in panic rout all over Etruria.

That first lesson should have been enough, yet it was only the beginning. As Hannibal marched southward, his army in higher spirits than ever, Rome

BRONZE HELMET
EARLY ITALIC, NOT LATER THAN XI CENTURY B.C.

desperately scraped together an army of seventy thousand, many of them raw militia and citizens, forgot the viciousness of political appointments, and dispatched this horde under three quarrelsome consuls to meet the enemy. While the consuls bickered, Hannibal marched circles around them. When they should have been planning, they were squabbling; and Hannibal captured all their supplies and equipage. Finally, before the town of Cannae, they suddenly faced the main Carthaginian force and found themselves forced to fight. Hannibal had aligned his troops so that the wind blew from them into the faces of the Romans, who would have to fight in choking clouds of dust, or retreat to secure fresh supplies. Consul Varro, whose turn it was to command, did not consult his co-commanders, but signaled to join action.

Unfortunately for Rome, Varro was nothing more than a big business man. To pit himself against the Carthaginian fox was matching a pullet against a coyote. Varro's 55,000 legionaries were almost twice as strong as Hannibal's 32,000, but the Carthaginians were seasoned veterans. Varro had 6,000 cavalry against Hannibal's 10,000. But the chief difference between the armies lay in their commanders. Varro knew what would happen to his political future if he failed, so he followed the time-tried Roman copybook method, stolidly lining up his army in the conventional manner, with his heavy infantry in the center, the cavalry screening his wings.

It seemed to his inexperienced eye that Hannibal had done the same thing with his smaller force. Full of confidence, he made the fatal signal, not noticing that Hannibal had weakened his already thin center by taking out 12,000 soldiers and placing them in the rear in two solid columns. Out cantered the Roman cavalry to open the fight, only to break and retreat hastily as the better Carthaginian horse charged to meet them. Paying no attention to this skirmishing, the stolid legions marched steadily ahead and met the Carthaginian infantry.

Instantly the African cavalry dropped its pursuit of the Romans, wheeled, formed into a solid group in the rear and attacked furiously. Now the discipline of the legions came into play. There was no panic. Rome struck back as steadily as though she were not fighting two

Courtesy National Archeological Museum, Athens

THE BUST OF LEONIDAS,

HEROIC KING OF SPARTA, WHO FELL WITH HIS GALLANT THREE HUNDRED AT MARATHON. STANDS TO-DAY IN ATHENS MUSEUM.

actions at once, front and rear. Then the strategy that had passed unnoticed came into play with a fatal crash. The sides of Hannibal's trap were open. He slammed them shut by throwing his reserve infantry across, closing the Romans in on four sides.

All that bitter day the slaughter raged. Roman courage and determination struggled vainly against Carthaginian hatred and skill. When night fell

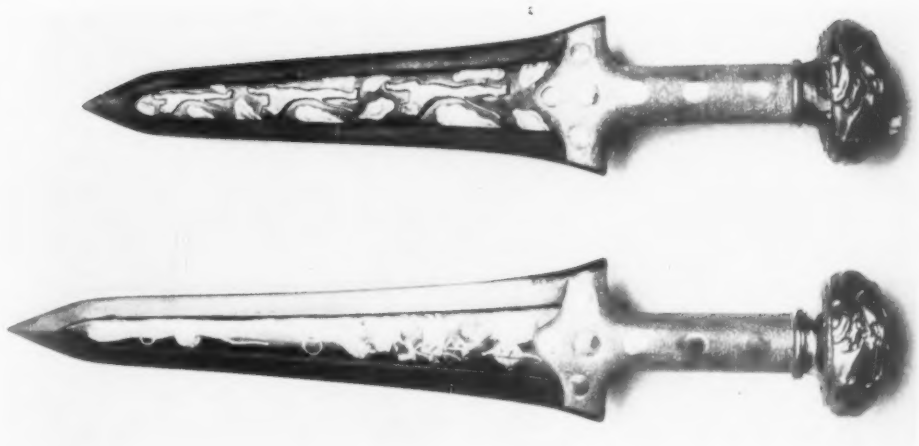
and the exhausted Carthaginians had nothing more to do, 40,000 Roman infantry and 2,700 cavalry lay dead upon the field, and the rest had fled in utter rout. Hannibal sent home with his message of victory a bushel basket of the gold rings of their rank worn by Roman knights who had perished.

The story could be carried on almost indefinitely until the Middle Ages, when the wars carried on by the mercenary soldiers in the pay of ambitious princes simulated the utmost fury, and developed a crude strategy peculiar to the local conditions. However, the *condottieri* were careful not to kill or mutilate too much. War was a matter of the employer who paid best, and in whose service the loot and kidnapping and rape were the most satisfactory. Moreover, with the passage of time and fresh inventiveness, war had passed into another stage of development, the age of protective armor. But tactical inventions for both offense and defense have kept close together all through the ages, and no sooner had the knight learned to sheathe himself in steel than the longbow and the crossbow developed a power that enabled the archer and the crossbowman to drive a "clothyard shaft" or a quarrel through the finest armor at fifty yards or more.

Another step in time reveals the first master strategist's attempt to coordinate sea power and land power. Napoleon had no peer as a leader of armies. So when he, like the present Germans, mobilized a huge army at the Channel ports and announced that he would invade England, the European world shivered. Carefully he brought together a great allied Franco-Spanish fleet, and told his admirals: "Give me command of the sea for three days, and England is mine." Trafalgar was the answer, and the dictator's project failed because his strategy and tactics were not the equal of the British.

With the introduction of gunpowder at the close of the Middle Ages, a third modifier entered the military field. The horse had given mobility and speed, armor bodily protection of a sort, and now powder enormously increased offensive power; to such a degree that neither protection nor speed availed against it. Thereafter the changes that occurred between Napoleon's day and our own were chiefly concerned with size and fire. Then overnight the airship came into being, totally changed the relations of the different arms, added an entirely new factor which had to be taken into the gravest consideration, and made all the old ideas of speed and striking force seem childish play. The first World War gave us the beginnings of air warfare: primitive, crude, almost as fatal to its exponents as to its opponents, but promising a development whose end is not by any means yet in sight. Hand in hand with air warfare came the armored tank, that lumbering, fire-breathing dragon whose initial foray so completely crushed the German troops against which it was used. Both strategy and tactics were profoundly modified by these new weapons. They were further modified by the adoption of poison gas.

World War manoeuvering, however, revealed very little strategical advance over that of previous wars. The tactical differences caused by the use of the new weapons on land and the submarine at sea were not especially significant. The vital thing was that possession of more powerful weapons, and a strategy that carefully prepared the ground long in advance of actual military operations, seemed to fill the aggressors with the Assyrian spirit of ruthlessness, gave them such a sense of fitness and superiority that they over-expanded, and finally trapped them by so increasing the weight of their men and equipment as to nullify mobility and create so onerous a burden upon the home population that the strain



BRONZE DAGGERS WITH METAL INLAY FROM MYCENAE, 1600–1100 B.C.

weakened them, enabling the allied forces to hammer out a stalemate.

No one is more keenly aware than the writer of the shortcomings of such an account as this. It does not pretend to, and could not possibly, evaluate even the major points of the evolution of scientific warfare of the present. All it hopes to do is to show a few of the features, illustrating them by historic examples, and referring the interested reader to such authorities as Jomini, Clausewitz, Fuller and others; and perhaps to touch very briefly upon the present war and show the most notable recent strategic advance.

When Germany entered upon this present campaign her evil geniuses, working in closest harmony with the Great General Staff and the financial and economic authorities, made possible quick triumphs in selected areas largely by the

Photo by the Author.

LOOKING ACROSS THE WHITE RUIN AND SAPPHIRE AEGEAN

FROM THE TELESTERION AT ELEUSIS TO THE LOW POINT WHERE HAUGHTY XERXES SAT ON HIS GILDED THRONE TO WATCH THE ANNIHILATION OF HIS FLEET IN THE GREAT BATTLE OF SALAMIS.

use of an incredible long-range weapon: the psychology of fear and defeat. Coupled with that ran a system of espionage and sabotage compared with which the efforts of World War days were infantile. The story should be familiar to every adult mind, since it unraveled its tangled skeins of cruelty and destruction in Austria, Czecho-Slovakia, Norway, Belgium, Holland and devastated France. The obscene brutalities of 1914–18 have been surpassed in the German effort to destroy not only the physical courage and will-to-resist of her enemies, but their very souls as well.

This effort will fail, so far as Britain, China and the United States are concerned because the psychology upon which the strategy is based is false. We know completely the vileness of such an effort, the subtle insinuations of subversive propaganda and fifth column activities; we hear and are unintimidated by the threats and pretense rumbling out of the Far East; we recognize and discount those "foes of our own household" who by their inchoate treason aid and comfort the enemy. And we are basing a sound strategy, a wise tactical implementation and training upon our knowledge, convinced that we wish no part of war, but recognizing that if fight we must, our salvation will rest in our comprehension of the now complicated strategy which both precedes and accompanies operations, and our ability to excel any possible opponent in the tactical use to which we put our vast and hitherto hardly tried spiritual and material resources.

SCIENCE AND SOCIETY

WHILE scientific knowledge is providing unparalleled instrumentalities for achieving an orderly and humanly significant social life, science can not minister effectively nor safely to man and his society until it is oriented to our contemporary social life and coordinated into the complex functioning of our culture. To-day ignorance of human behavior and social organization and the prevailing unawareness of the functioning of our culture are blocking the full utilization of scientific knowledge. Thus we have the ironic and tragic spectacle of science contributing effectively to man's physical comfort or to his destruction, but seemingly helpless to advance his social and cultural aspirations.

The relation of science to society involves more than questions of the organization and immediate application of scientific results through technology and professional practice; it raises the more important issues of the place, function and especially the responsibilities, of the scientist in the present-day social situation and cultural confusion. There is a serious lag between scientific knowledge and its application to human needs, but there is also a widening gap between the scientist and the layman, to whom science and technology often appear as esoteric pursuits.

Moreover, the very rapid progress of scientific knowledge has rendered obsolete much of our traditional culture and ancient beliefs and in so doing has fostered individual confusion, distortion and insecurity. Personalities so disturbed can not function adequately as individuals nor participate as members of a society which is seeking resolution of its difficulties by voluntary cooperation. The increasing social disorder, affecting those countless millions in all lands who have been cut loose from their inherited social, economic and ethical moorings, has rendered them subject to devastating exploitation by distorted, but plausible, fanatics. To-day society itself has become the patient.—*Josiah Macy, Jr., Foundation Report for 1937–1940.*

SAILING CRAFT OF RECIFE, BRAZIL

By Dr. E. O. HULBURT

NAVAL RESEARCH LABORATORY, WASHINGTON, D. C.

On the voyage to Brazil in September, 1940, the eclipse expedition of the National Geographic Society and the National Bureau of Standards spent several pleasant days at Recife, the capital of the State of Pernambuco. This is a city of about 400,000 inhabitants and is the most eastward port of Brazil. It is of old Portuguese architecture and being built around several tidal estuaries is often referred to as the Venice of South America. Statistics of Recife showed that, in 1939, of 1,503 commercial craft which used the port, the motive power of 555 was sail. It needed only a single glance at the harbor to bring a sparkle to the eye of any yachtsman. The water was thronged with two fascinating types of sailing craft, the *barcaças* or coastwise schooners and the *jangadas* or sailing rafts of balsa wood.

The climate conspires to make the region a sailor's paradise, for the southeast trade wind blows steadily a perfect 10 knots night and day unceasingly. It is an on-shore breeze and one can sail in either direction along the coast with the wind rarely forward of the beam. The sea is always smooth, occasionally flecked with a few whitecaps, and a warm surf tumbles gently on the sandy beaches. It is said that storms never come. In the rainy season from April to August there are plenty of scattered showers, but through it all the sea breeze blows sweetly, the mainsheet pulls steadily and the boat slips along on a gentle tropic sea with the bowsprit swinging to the Magellanic Clouds. No wonder there was a never-ending procession of little white dots down the coast line as far as the eye could see. They were the barcaças, the trading schooners of Pernambuco, bringing cocoanuts, lumber, sugar, coffee, pineapples and melons to the big city.

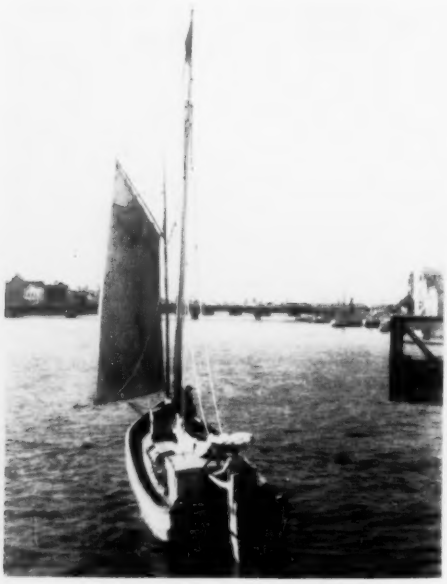
The barcaças were 50 to 70 feet in length, 10 to 14 feet beam and about 5 feet draft when normally loaded. Like

TWO-MASTED BARCAÇA.

THREE-MASTED BARCAÇA.

JANGADA UNDER WAY.

all freight-carrying craft they were staunchly built, the planking being 2 to 4 inches thick. They were moderately bluff bowed with hard bilges and long easy lines. They had no center-board and practically no keel, and would stand upright when allowed to ground out over the eight-foot tide. The rudder was outboard and worked by a tiller; there was no bowsprit. Whether the barcaça had two or three masts appeared to depend on the taste of the owner or designer rather than on the size of the boat. All the sails were gaff-headed, being laced to the gaff, boom and mast with spiral lacing. There was a minimum of metal fittings. The front mast was stepped in the peak of the bow like the mast of a catboat. The sail of this mast, called the "mizene," overlapped the next mast aft by 6 to 8 feet. There was a lift toggle from the end of the mizene boom to the eye of the next mast. In coming about one or two men at the toggle hoisted the boom to a high angle until it passed by the mast and then lowered it again. Evidently the gain in sailing effect from the overlapping mizene more than compensated for the awkwardness of the maneuver. The sails were baggy and well cut. There were no reef points and no standing rigging or stays of any kind on the masts. This was eloquent testimony of



BARCAÇA ENTERING THE HARBOR.

the geniality of the weather. The masts were of a tough and heavy wood which by dint of much questioning and thumbing of the Portuguese dictionary I discovered to be "mast wood." Each boat carried a balsa wood raft or jangada as a tender, sometimes rigged for sailing and sometimes just plain raft.

Names of barcaças were Zulaida, Sonia, Lindya, Ametisto, Allianco, Bomconselho and many saints. The barcaças were innocent of engines; they went places by sail. At almost all hours of the day one could see several working their way by short tacks up the mile-long narrow outer harbor, drop their mainsails, shoot through the draw and continue under mizene alone to anchorages or berths in the inner harbor.

The jangadas were sailing rafts of balsa wood logs used for fishing and pleasure. They were 14 to 20 feet long, 3 to 5 feet in width, and made of 5 to 8 logs joined together by long wooden pins. Each log was roughly narrowed at the ends and so chosen and put together that the jangada narrowed at each end with some upward curve or sheer at bow and stern. A center board was thrust down a slot between the center logs. Steering was with a long oar. The mast was very curved and the sail three-cornered with a sprit. The upper mast step was a strong piece supported athwartship on stout legs about two feet high. The lower mast step was one of several holes in the logs, and by selecting a particular hole the mast could be set at a port or starboard slant to suit the sailing conditions. When running before the wind a temporary backstay to the top of the mast was often used. The sail was lowered by disengaging the sprit, gathering the sail around the mast and unshipping the mast. The jangada pictures were kindly given to me by Mr. Arthur A. Hoag, of Brown University, who was as much interested as I in the sailing activities of Recife.

The home port of the jangadas ap-

PUSHING AND SAILING A JANGADA UP THE BEACH.

peared to be the nearest beach, although at times they did not scorn the harbor entrance. But their usual influx and efflux was by way of the surf. The larger sizes were distinctly heavy and required several men to push them on rollers above the high tide mark. They were not painted, and once on the beach they were immediately propped up or tipped on the side for drying. The jangadas were apparently planned to progress mostly by sail, for there was no provision for rowing and they were heavy to paddle; the only oar they carried was the steering oar. Under sail they were fairly agile and would work to windward; in fact they sailed as well as might be expected. The usual crew was one or two barefoot people, one perched near the mast step and the other on the stern seat with the steering oar. It was said that they often go fifty miles off-shore. On the occasion of a visit from President Vargas we watched a parade of over fifty jangadas sailing a sort of "follow-the-leader" in single file. It was a pretty sight.

STUDENT LIFE IN THE UNIVERSITY OF PUERTO RICO

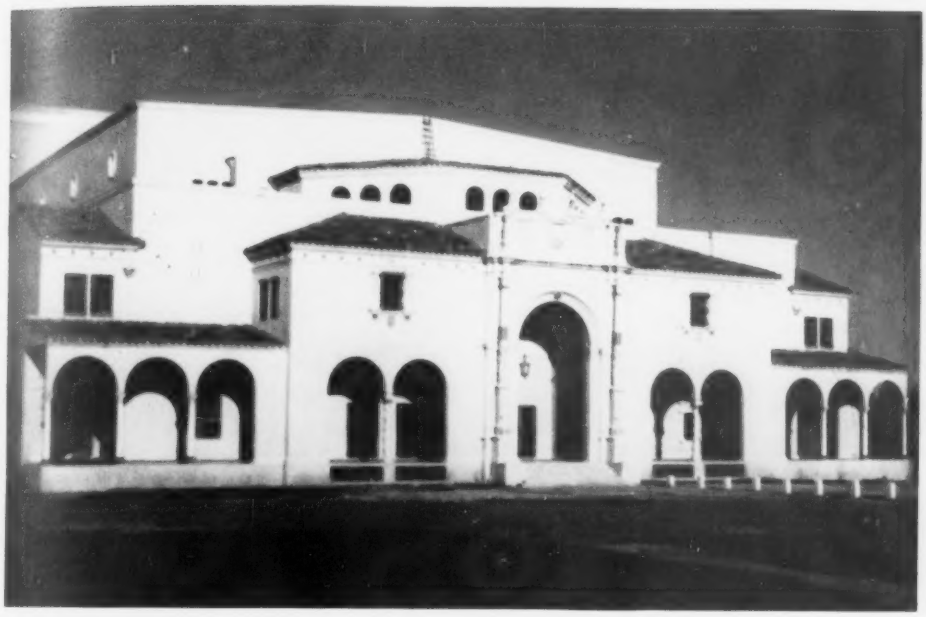
By Dr. JAMES G. NEEDHAM

EMERITUS PROFESSOR OF ENTOMOLOGY AND LIMNOLOGY, CORNELL UNIVERSITY

AFTER retirement from half a century of teaching of American students, I was recalled to service by an invitation to become a visiting professor for a term in the University of Puerto Rico. I was curious to know what Puerto Rican youths are doing and thinking, and I went gladly. I lectured to a large class and went afield with a small one. I attended public lectures, concerts, athletic meets and social affairs in great variety, and I talked with many students privately. I saw Puerto Rican youths at work and at play, in lecture rooms and in laboratories, on the campus and in the mountains, in private conferences and in assemblies; and in all, I had great pleasure in associating with them.

THE ADMINISTRATION BUILDING WITH THE ROOSEVELT BELL TOWER. THERE ARE CHIMES WITHIN AND AN AVIATION BEACON ON THE PEAK OF THE TOWER.

I found them quite like students elsewhere; perhaps a little more volatile than ours at the North and a little more prone to argumentation; but, gay, carefree, ready to dance to the first strains of suitable music; but withal, thoughtful and very conscious of being in training for life. The work done there by my classes would stand comparison with that done by similar classes at home. The average of intelligence and of industry was quite as high.



THE AUDITORIUM OF THE UNIVERSITY OF PUERTO RICO
FUNDS FOR IT WERE PROVIDED BY THE PUERTO RICAN RECONSTRUCTION ADMINISTRATION.

The slight differences are mainly traditional in origin. Puerto Rico is essentially Spanish, and young Puerto Rico is proud of its Spanish traditions. It never forgets that the discovery of the New World began in its own neighborhood of islands, and was made possible by the patronage of a Spanish queen.

The university is bi-lingual. Professors are free to conduct their work in either English or Spanish, as they may prefer. Lectures in scientific subjects are all given in English. The students all know English, but they do not use English except when necessary, and then haltingly, and with none of the fluency that characterizes their use of their native tongue.

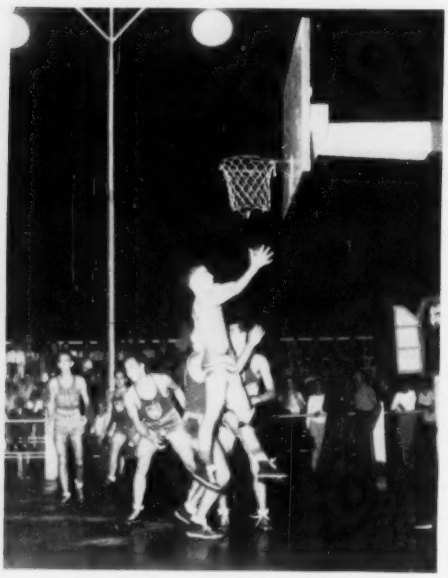
There is much discussion of governmental matters among Puerto Rican students outside the classsrooms. They study our Constitution, and ask why its principles are not applied in the Island. They are puzzled as to why our government, that their fathers welcomed a generation ago, still rules the Island with dictatorial hand; why it calls them Americans and yet still withholds full citizenship from them; why it does not allow them to choose their own rulers and why it does not make them responsible for their own affairs.

Many of the best students would like to continue their studies in our continental universities. A few of them are able to do so. A very few of our northern students do graduate work in Puerto Rico. There should be more students going both ways; for the Puerto Ricans would expand their knowledge of our great country, and our own students would learn something of the conditions of life in the tropics. Ours would have all the advantages of sanitary living conditions in a beautiful environment, with colleagues who know the Island well and are eager to aid them in their own researches upon tropical life.

Without waiting for the establishment of the proposed great Inter-American

THE ATHLETIC ASSOCIATION MASCOT

University that was planned by the President's committee last year, some of its most desirable objectives might be had by exchange of students with the university already there. The more that our youths who differ in upbringing are permitted to seek the truth together, the better will be the relations between them as citizens of a common country.



A BASKETBALL GAME
STUDENTS OF THE UNIVERSITY OF PUERTO RICO IN AN INTRAMURAL GAME.

The University of Puerto Rico is only forty years old. It was begun at Fajardo in October, 1900, as a normal school for the training of teachers for the Island. It was removed to Rio Piedras, a suburb of the Capitol and principal port city of the Island, San Juan, in 1903, and made a university in name and in purpose; and with continued and substantial support from the legislature of the Island, it has now attained to the stature of a real university. During the past decade I have visited it three times at five-year intervals, and I have been delighted to see the progress it has made.

In the matter of housing the Puerto Rican Reconstruction Administration has been a godsend to the university. Beautiful new buildings have been erected where most needed; dignified, serviceable and well designed for their uses. The presence of such buildings has made a marked improvement in the attitude of the students toward their university. They take pride in its appearance and in its maintenance in good order.

Recent improvements have followed a plan of future development, and have included some effective landscaping of the front of the campus. There is a fine view westward from the front of the main buildings, and I have often lingered there at time of sunset to enjoy it. A broad lawn slopes downward to the three front entrances. The direct path to the middle gate is bordered by the plume-crowned columns of a double line of royal palms. The semicircular drive that borders the lawn and runs out to the two carriage entrances, encircles a bordering line of fig trees: broad bushy

ELECTED GIRL REPRESENTATIVES OF THE STUDENT BODY

CENTER, WITH TROPHY, IS THE UNIVERSITY QUEEN, SENORITA EDNA MENDEZ (WHO IS NOW A GRADUATE STUDENT AT CORNELL UNIVERSITY); THE OTHERS, "MADRINAS," REPRESENT SPORTS (LEFT TO RIGHT) BASKETBALL, TENNIS, FENCING AND TRACK. THE LADY BEHIND THE QUEEN IS AN INSTRUCTOR IN PHYSICAL EDUCATION.

trees, with masses of heavy evergreen foliage, multiple boles and dangling aerial roots. Beyond the gates and the town an undulating mass of foothills stretches away inland to the high mountains in the far distance, and outward they slowly fall away to the shoreline of the blue Atlantic. The students may well be proud of their native homeland, for it is one of the most beautiful islands in the world.

The university is doing its best to keep in touch with educational trends by granting leaves for study in the States to members of its teaching staff, and by maintaining exchanges of professors with some of our best universities. Our men who go down there return to speak of their experience as a great privilege. They have had a chance to study life in the tropics where there is a great variety of environmental conditions near at hand, and where the people are very hospitable. The winter climate in Puerto Rico is delightful.

Here at this university is the best place in the New World for the improvement of cultural relations. It is the place where our community of interests in seeking knowledge is unquestioned. It is the place of greatest advantage for the growth of mutual understanding.

SUBSISTENCE MANUFACTURING[1]

By Dr. RAYMOND CRIST

DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF ILLINOIS

Thou shalt not muzzle the ox that treadeth out the corn.
The labourer is worthy of his reward.
—I Timothy 5: 18.

ACCORDING to many text-books man goes through various phases in his upward march from the hunting and collecting stage of economic development, through shifting to sedentary agriculture, and on to the embryonic stage of manufacturing—this word used in its original sense, *viz.*, hand-made. This sequence is said to be the natural one, each step supposed to represent an economic and social advance over the one preceding it. Occasionally one or more steps in this evolutionary process have been skipped; furthermore, they do not, in the order named, always mean progress; indeed, under certain conditions a change from agriculture to manufacturing may, in the long run, signify a retrograde movement for the people concerned.

In the semi-arid region around Barquisimeto, Venezuela, a relatively low-lying area swept over by the drying trades much of the year, the early explorers—here both Spaniards and Germans—found an Indian population that was not at all highly developed. One great boon to these primitives was the introduction of the goat, an animal admirably adjusted to the xerophytic vegetation of that area. From then on there was much more stability in the food supply, and with the rise of Barquisimeto as a regional capital, because of its key position where the routes from mountains, plains and sea converged, the people became relatively prosperous. The economy of the rural people began to change from that of hunting to that of grazing with some agriculture.

With the expansion of trade following the development of routes, some industrial development was possible, and there was conveniently at hand an indigenous plant, the cocuiza (*Fourcroya Humboldtiana*), a perennial with smooth leaves five or six feet long, containing strong fibers known as Fique, valuable for the making of hammocks, sandals, ropes, twine and sacks. It is also used for making a popular potent rum called cocuy, similar to Mexican mezcal. This useful and drought-resistant plant can be grown with ease in Venezuela in extensive areas, at present almost completely unproductive. It does not quickly use up the soil elements, and thrives in dry, stony places where some lime is present. After the first year it does not require much attention. The woody part of the trunk gradually hardens with age and the fiber-bearing leaves are ready to cut when the plant is six or seven years old. At least 25 leaves should be left on the stock at all times during the producing period, which ends when the plant has attained 18 or 20 years.

The leaves are tied up in bundles and carried or hauled to the machine which extracts the fiber. It is then hung out to dry. Many phases in the elaboration of useful articles out of this desert plant, which were formerly done by hand, are now done by machines. In Barquisimeto there is a sisal sack factory with a capacity of 1,000 sacks a day, which has a machine for each of the twenty operations necessary in the making of the

[1] The work on this article was made possible by grants from the John Simon Guggenheim Memorial Foundation and from the Graduate Research Board of the University of Illinois.

finished product; yet people in the country who make sacks in their homes on hand looms still compete successfully with the products of the mass production factory.

Two families who are competing with the machine were visited on August 4, at El Rodeo, on the road to Qúibor. The Perez family is typical. Up to five years ago this family lived almost exclusively from its flock of goats, which were kept at night in a corral near the house. This source of steady income was suddenly snatched away by the death of all the goats from a plague, and the family was confronted with the task of making a living by other means. The goat corral was immediately planted in cocuiza. This is not more than half an acre, but it is something. But since it takes at least five years before the plant produces leaves with fiber of the proper tensile strength, something had to be done in the meantime for daily bread. Then a hand loom was built. About this time Mr. Perez was killed in one of the local revolutions which have victimized the poor people of more than one Latin American republic. His widow, now only 29 years old, who was married at the age of 12, and his four children were left completely destitute. But the feeling of family solidarity is strong, and life's realities had to be faced. The older woman, her daughter and four grandchildren set to work making sacks with fiber borrowed from the local storekeeper.

Every step in the manufacture of sacks, except removing the fiber from the leaves, is done by the family. The cocuiza fiber is kept in the house so as not to become too dry. The workers sit on the bare earth floor inside the house while making string. They kindly moved outside awhile so that pictures could be taken. The little girl hands a few strands of the fiber to the grandmother, who twists them into a string by rubbing them on her thigh, which from constant use at this work is just one huge leathery callous. The girl keeps feeding the fiber onto her grandmother's tough thigh,

MACHINE-EXTRACTED COCUIZA FIBER DRYING AT EL RODEO.

L. I. Williams

A STAND OF COCUIZA

THE FORMER GOAT CORRAL OF THE PEREZ FAMILY WHICH IS NOW PLANTED IN COCUIZA.

from which comes a thick heavy string which she doubles over in her hand preparatory to staking out in the yard for shrinking. After that it is wound on a spindle a foot long and is ready for use on the loom.

MAKING COARSE STRING FOR WOOF

The finer string that is strung in the loom is made by a different process. The oldest boy, a fine young lad, takes in his left hand a little hand-made frame in which there is fastened a tiny fly wheel on a rod. Then with his right hand he grasps a wooden handle some eight inches long to which is attached a rawhide loop. By working the handle deftly up and down the thong grips the rod and the wheel keeps turning round and round in the same direction. The fiber attached to the farther end of the axis is twisted into a fine string which lengthens as more strands are fed into it. As it gets longer the boy moves away from his mother until there are 30 or 40 feet of string. This is wrapped onto a ball and the operation is repeated.

Thus the entire family is kept busy, often from five in the morning till eleven at night, either at the loom, making string of one grade or another, or running errands. The finished products are carried, usually on the heads of the women, to the local storekeeper, through whom they are sold. He makes a profit in supplying the fiber and in selling the sacks, and unfortunately all that the family consumes in any way must come from the same store. The result is that they are always in debt to the storekeeper, just as the Mexican peon was to the "tienda de rayo." If the family has enough black beans to keep body and soul together, they rejoice. There is little use to ask how much the family makes in money. It is never enough to meet their very meager expenses. Money is in reality rarely seen. For the producers this is barter economy at its worst.

A neighboring family was visited, and there was the same story of poverty, misery and squalor. Fortunately, the man of the house was alive and active. He had two looms, for different grades of sacks. Most of his time was spent bent over a loom. In front of the house was

a pile of wood from which he was about to make charcoal. The problem of obtaining enough fuel for cooking is everywhere acute. It hardly seemed possible that his little house, which appeared to be a part of the semi-arid natural landscape with which it blended so perfectly, could be the scene of such unremitting, unremunerative drudgery.

These families are just one jump ahead of starvation. When sickness comes, utter destitution is their lot. Aid from the storekeeper means more indebtedness. The Federal Government did help them out last December with some medicine, but there is a crying need for education in the rudiments of hygiene. The drinking water is taken from an artificial pond, or jaguey, ideally located behind the store, to become what really amounts to a cesspool. As long as this is used without boiling, sickness is inevitable.

Once the patient or patients are able to be on their feet, they must jump into the work again. Their life is little more than a treadmill—an existence, not a living. They are living on the land, yet are completely uprooted from it—not drawing any of their food from it directly. Although bound to the land by only a very slender cocuiza thread, they are unable to cut loose and move off. They are condemned to suffer most of the privations of the savage, without his sense of personal freedom; not only is their horizon narrower, they have no opportunity to develop even his rude resourcefulness. Perhaps it is just as well that they are geographically and socially immobile—they thus remain unaware of blessings that they could never hope to enjoy.

There was not a stick of furniture in the house—not even a box to be used as a chair. The family slept in dirty hammocks suspended from cross-pieces. There was not even a tiny flower pot, an object often seen in the most lowly hut. Life here is too real and earnest; there

STAKING STRING OUT TO DRY
THE BIG CACTUS PLANT IS ONLY FIFTEEN OR TWENTY FEET FROM THE HOUSE.

is no time for cultivating a taste for the beautiful. Yet, in all fairness, it must be said that these people with a horizon bounded at farthest by the cactus plants a few feet from their home received us with grace and dignity. They were at ease and made us feel at ease. They

L. I. Williams
MRS. PEREZ AT HER LOOM

MR. MENDEZ' HOME, HIS WIFE AND FOUR CHILDREN

NOTE THE SECOND LOOM UNDER THE LEAN-TO SHELTER AT THE LEFT. THE PILE OF WOOD IN THE FOREGROUND IS TO BE MADE INTO CHARCOAL. THE MAN TO THE LEFT IS THE LOCAL STOREKEEPER.

MR. MENDEZ HARD AT WORK ON HIS LOOM

ONE OF HIS POORLY CLAD CHILDREN STANDS AT THE RIGHT.

kindly went into details in answering our questions and were neither shy nor forward—a distinct contrast to the pseudo-sophisticated storekeeper and his hangers-on, who lived on the road and were in daily contact with many people. These people, cheerful, courageous and industrious in the face of appalling conditions, will never need to read Emily Post.

The big question for these marginal families is not whether they will continue all their lives being in debt to the storekeeper, but whether technological progress will not wipe out even their present means of subsistence. Already the machine has taken over the work of extracting the fiber from the leaves. There is the big sack factory in Barquisimeto to compete with. These families are past the self-sufficient stage in economy. They can no longer directly satisfy their wants; they must do so indirectly through the concurrence of many others in an enormous chain of producers and consumers. If one small link breaks, the whole mechanism stops short. They will continue to be workers if "business continues as usual," but they will be on the scrap heap with even a slight technological change. It is no credit to civilization if people in it look with regret upon the savage state. Yet merely paying these people a bonus if or when they become technologically unemployed would only mean temporarily anchoring submarginal operatives on submarginal land.

The word integration has been overworked, but it is still useful. There are thousands of people in the world like these two families in the interior of Venezuela who must be integrated not only into their regional economy, but also made to fill a niche in our world-wide mechanized society. The Huns and Vandals would have been quite unable to shatter the Roman Empire if the competition of enslaved captives had not created within the Empire a great body of unemployed "freemen," who, tired of bread and circuses, felt that any change would be for the better. If the families discussed in this paper, and their peers all over the world, are gradually "freed"

MAKING FINER STRING FOR WARP

by technology without at the same time being able to achieve a sense of "belonging" to our present society, they may confidently be expected to do for it what the Huns and Vandals did for the Roman Empire.

Why hesitate? Ye are full-bearded men,
With God-implanted will, and courage if
Ye dare but show it. Never yet was will
But found some way or means to work it out,
Nor e'er did Fortune frown on him who dared.

—E. R. TAYLOR.

TELEPHONE LINES HEAVILY FESTOONED WITH SLEET AND SNOW

THESE STURDY SENTINELS OF COMMUNICATION HAVE WITHSTOOD THE FURY OF THE STORM AND EACH LINE IS STILL CARRYING ITS QUOTA OF MESSAGES.

YOUR VOICE AND THE TELEPHONE

By Dr. FRANKLIN L. HUNT

BELL TELEPHONE LABORATORIES

If some one at New York could shout loud enough to be heard at San Francisco and some one there should shout back immediately on hearing the message and loud enough to be heard at New York, the New Yorker would have to wait over eight hours for a reply because it would take that time for sound waves to traverse our continent twice. By substituting electric for acoustic waves, however, and wires for the air this fantastic supposition becomes reality and the reply to words spoken in an ordinary tone of voice comes back so nearly instantaneously that there is no noticeable delay. We have become so accustomed to transmit speech thus over great distances by telephone, that we seldom stop to consider that only within the short span of a single lifetime in the long history of human endeavor has it been possible to project one's voice more than a few hundred feet. Sixty-six years ago the first words were sent over telephone wires, twenty-six years ago our continent was first spanned by telephone and only within fifteen years has commercial transoceanic telephony become practical. Since then progress has been so rapid that it is now possible to sit in our own homes and call nine out of ten of the approximately 40 million telephones in the world of which more than 21 million are in the United States.

This vast communication system has been accommodated to the unique characteristics of the human organs of speech and hearing, and many years of effort have been spent by scientists and engineers to learn how best to transmit the feeble energy of the human voice over telephone lines.

The Organs of Speech

The human speech organs are a remarkably flexible and versatile arrangement for producing tones of a wide range of pitch and quality and yet as a mechanical structure they are surprisingly simple. Air from the lungs, which acts as a bellows, passes through the wind pipe to the vocal cords—two muscular bands stretched across the upper end of the windpipe to form a slit. The passage of air past the edges of the vocal cords makes them vibrate, thus producing sounds which pass up to the mouth and nasal cavities where they are modified by the mouth, tongue and teeth and given the distinguishing characteristics of speech. The vowel sounds are the low-pitched components of speech and they carry most of the energy. Intelligibility, on the contrary, is largely due to the high-pitched consonants added by the tongue, teeth and lips. A satisfactory telephone system must therefore transmit high enough pitches to include these consonant sounds.

The Organs of Hearing

The mechanism of hearing is more complex than that of speech. The sound heard impinges on a diaphragm in the outer ear beyond which is a group of three small bones. They convey the vibrations from the diaphragm to the inner ear, where the real organ of hearing is located. It consists of a spiral cavity filled with liquid and divided longitudinally into two sections by a flexible membrane. Along this membrane are distributed thousands of nerve fibers—about 30,000 in all. This flexible membrane vibrates under the sound impulses

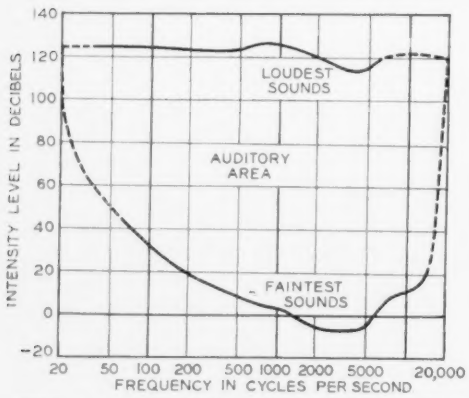


FIG. 1. AUDITORY SENSATION AREA WHICH SHOWS THE RANGE OF PITCH AND INTENSITY THAT THE HUMAN EAR CAN HEAR.

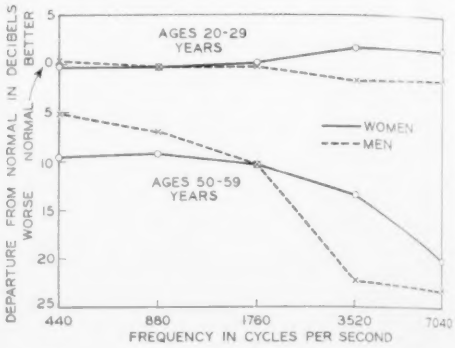


FIG. 2. HEARING LOSS COMPUTED FOR DIFFERENT AGE GROUPS. NOTE DECREASE IN ABILITY TO HEAR AT HIGH FREQUENCIES IN CASE OF OLDER GROUP. DATA OBTAINED AT THE NEW YORK AND SAN FRANCISCO FAIRS, 1939.

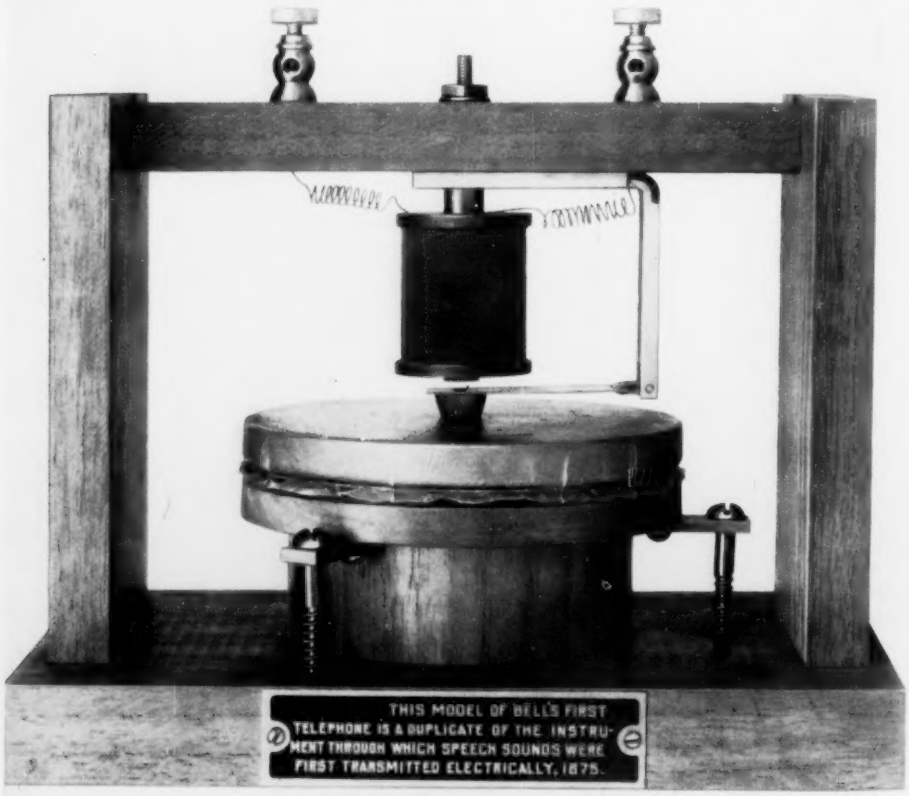

THIS MODEL OF BELL'S FIRST TELEPHONE IS A DUPLICATE OF THE INSTRUMENT THROUGH WHICH SPEECH SOUNDS WERE FIRST TRANSMITTED ELECTRICALLY, 1875.

FIG. 3. FACSIMILE OF BELL'S ORIGINAL TELEPHONE THROUGH WHICH SPEECH SOUNDS WERE FIRST TRANSMITTED ELECTRICALLY IN 1875.

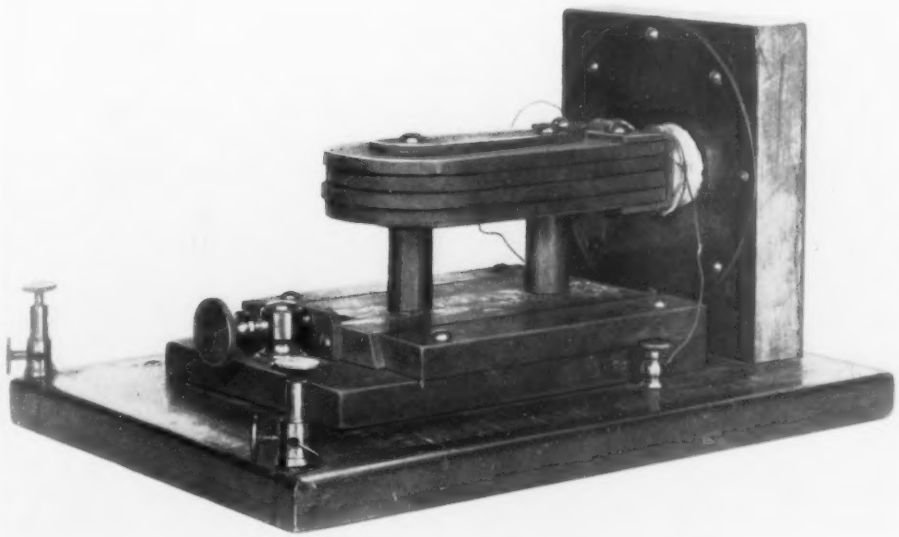


FIG. 4. THE FIRST COMMERCIAL TELEPHONE

PERMANENT MAGNETS PROVIDED THE MAGNETIC FIELD. NO BATTERY WAS REQUIRED BUT THE VOICE CURRENTS DEVELOPED WERE FEEBLE AND THE DISTANCE OVER WHICH CONVERSATION COULD BE CARRIED WAS LIMITED TO A FEW MILES.

and some of the fibers, depending on the pitch, respond and send signals to the brain. These fibers thus act selectively and make it possible to perceive sounds of a wide range of pitch.

Auditory Area

Curves which show the loudest and faintest sounds of all pitches which the ear can perceive enclose an area which is called the auditory area because it includes all the sounds audible to the human ear. This area is shown in Fig. 1, where the vertical direction represents sound intensity, and the horizontal the pitch or frequency of vibration. The lowest pitch which the ear can hear, such as the low rumbling tone of a large organ pipe, is about 20 vibrations per second and the highest, for example, the squeaks of machinery or of small animals, is about 20,000 vibrations per second. The lower curve shows the faintest sounds which can be heard, such as whispering or the rustling of leaves, and the upper the loudest tones which the ear can tolerate without pain. These curves come together at the lowest and highest audible tones. This indicates that the range of intensity that the ear can hear is much less for low and high pitch tones than for those around 1,000 vibrations per second; that is, two octaves above middle C on the piano.

The average fundamental pitch of a man's voice is about 125 vibrations per second and that of a woman's voice about an octave higher. There are also overtones or harmonics in the human voice which extend up to about 10,000 vibrations per second, but those above 8,000 contribute little to the intelligibility of speech. It is these over-tones which give the voice its individual character, however, and they vary both in pitch and intensity with each person.

Hearing Tests at the World's Fairs

At the World's Fairs in New York and San Francisco during 1939 and

FIG. 5. THE LIQUID TRANSMITTER THROUGH WHICH THE FIRST INTELLIGIBLE SENTENCE WAS TRANSMITTED BY BELL ON MARCH 10, 1876: "MR. WATSON, COME HERE, I WANT YOU."

1940 over a million visitors had their hearing tested at the exhibits of the Bell Telephone System. This is by far the largest hearing test ever conducted and provided a mass of data on the hearing of the average American citizen which has never been previously equaled. Some of the results, as analyzed by the Bell Laboratories' acoustical staff, are summarized in Fig. 2. The hearing loss for the age groups from 20 to 29 and 50 to 59 years are shown. The vertical direction indicates the hearing loss, normal hearing being marked O; and the pitch is plotted horizontally in vibrations per second. In the lower age group the difference between men and women's hearing is small but slightly to the advantage of men at the lower pitches and to that of women at the higher ones. In the age group from 50 to 59 years, however, the difference is much more pronounced. Men hear low-pitched tones somewhat better than women at these ages and women hear high-pitched tones decidedly better than men, although both show an average loss of about 10 db from the younger group. This survey indicates that one out of twenty-five persons has difficulty in hearing in auditoriums, one in 125 has trouble with direct conversation, and one in 400 has difficulty over the telephone.

Bell's First Telephone

No method of extending appreciably the distance that the human voice could be heard was devised until the advent of electro-magnetism, when scientists began to struggle with the problem of projecting the voice electrically over wires. Among them was Alexander Graham Bell, a professor of vocal physiology and a student of electricity. In 1875 he succeeded, for the first time, in transmitting

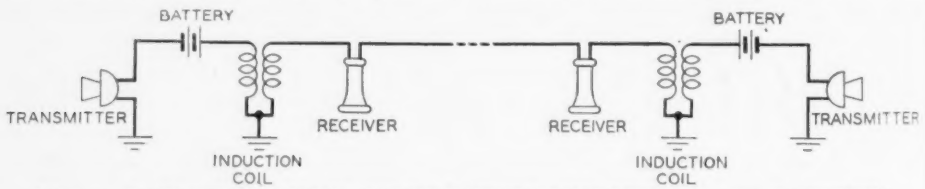


FIG. 6. EARLY TELEPHONE CIRCUIT (WITH MICROPHONE AND BATTERY) A SINGLE WIRE WAS USED; THE RETURN WAS THROUGH THE GROUND. THE INDUCTION COIL KEPT THE BATTERY CURRENT OFF THE LINE, THUS PERMITTING LARGER CHANGES IN THE RESISTANCE OF THE BATTERY CIRCUIT AND STRONGER VOICE CURRENTS. WITH THIS TYPE OF CIRCUIT AND A RETURN WIRE, TELEPHONE CONVERSATION WAS CARRIED ON BETWEEN NEW YORK AND CHICAGO IN 1892.

voice sounds with the apparatus shown in Fig. 3. To a thin leather diaphragm he attached a strip of iron held near the pole of an electro-magnet, which was excited by a battery. Induced currents of varying intensity were developed in the wires of the electro-magnet as the diaphragm vibrated and these fluctuating voice currents were carried by wires to an identical device at the other end of the line which reproduced the sound.

Voice Current Telephone

Bell soon found, however, that no battery was needed if permanent magnets were used instead of electro-magnets and the first commercial telephone, shown in Fig. 4, was made with a permanent "U" shaped steel magnet which had coils of wire on its poles. The vibration of the iron diaphragm near the magnet induced currents in the coils and these currents were carried to an identical apparatus at the receiving end. This telephone was able to carry messages only relatively short distances because it depended entirely on the energy of the human voice to generate the telephone currents and this energy is extremely small, so small in fact that a person would have to talk continuously for 100,000 hours to generate enough voice energy to light a 25-watt lamp for an hour.

Microphone and Battery

Early in his experiments on telephony Bell found that a metal rod attached to a diaphragm and dipping into acidulated water would transmit voice currents. When the diaphragm vibrated the rod rose and fell in the liquid and changed the resistance of a battery circuit which included the rod and liquid. This was discovered when Bell spoke the first intelligible telephone message on March 10, 1876, to his assistant: "Mr. Watson, come here, I want you." A reproduction of the transmitter used is illustrated in Fig. 5. It was presently discovered, however, that similar changes in resistance could be developed by the variations in pressure which a vibrating diaphragm could exert on a carbon button. This proved to be a more practical transmitter than the liquid type and is still used in modified form in commercial telephones. The carbon microphone and

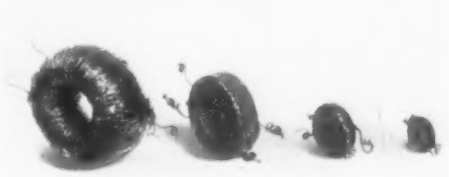


FIG. 7. INDUCTANCE COILS

COILS LIKE THESE WERE INSERTED AT CALCULATED INTERVALS ALONG TELEPHONE LINES TO EXTEND THE DISTANCE OVER WHICH MESSAGES COULD BE SENT TO DENVER, COLORADO, FROM NEW YORK, IN 1911. THE ILLUSTRATION SHOWS FOUR STAGES IN THE DEVELOPMENT OF THESE "LOADING" COILS. ALL HAVE THE SAME INDUCTANCE VALUE.

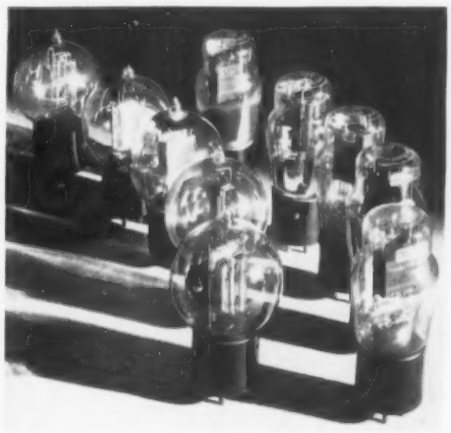


FIG. 8. VACUUM TUBES

USED IN THE "REPEATER" AMPLIFIERS TO AMPLIFY THE ATTENUATED VOICE CURRENTS AT PERIODIC INTERVALS ON LONG TELEPHONE LINES. THESE REPEATER TUBES MADE TRANSCONTINENTAL TELEPHONES PRACTICAL IN 1915. THE TUBES AT THE RIGHT ARE A RECENT DEVELOPMENT; THOSE AT THE LEFT ARE THE ONES LARGELY USED AT PRESENT. BOTH HAVE A LIFE OF MANY THOUSANDS OF HOURS.

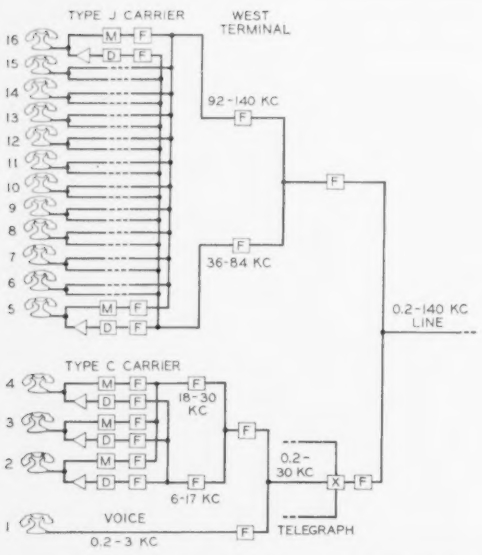


FIG. 9. CARRIER TELEPHONE SYSTEM

WHICH TRANSMITS SIXTEEN TELEPHONE AND TWO TELEGRAPH MESSAGES OVER A SINGLE WIRE. EACH TELEPHONE MESSAGE IS "CARRIED" BY A SEPARATE HIGH-FREQUENCY CURRENT.

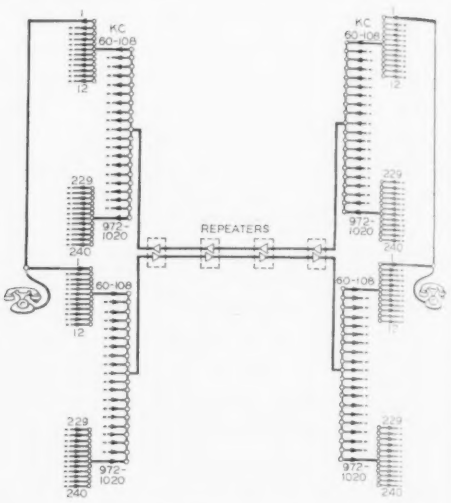


FIG. 11. COAXIAL SYSTEM

SCHEMATIC DIAGRAM OF NEW YORK-PHILADELPHIA EXPERIMENTAL COAXIAL TELEPHONE SYSTEM. IT CAN CARRY 240 TELEPHONES ON A SINGLE PAIR OF COAXIAL CABLES.

battery greatly extended the distances over which telephone messages could be sent and with circuits of this type, Fig. 6, using carbon transmitters and batteries, it finally became possible in 1892 to carry on a telephone conversation between New York and Chicago, but beyond that distance the messages became too weak to be heard satisfactorily.

Loading Coils

Soon scientists came to the rescue by discovering that inductance coils made of iron rings with coils of wire on them, when placed at calculated intervals along the line, would decrease the attenuation of the voice currents by counteracting the electric capacity of the lines. These coils, illustrated in Fig. 7, are known as loading coils and with them communica-

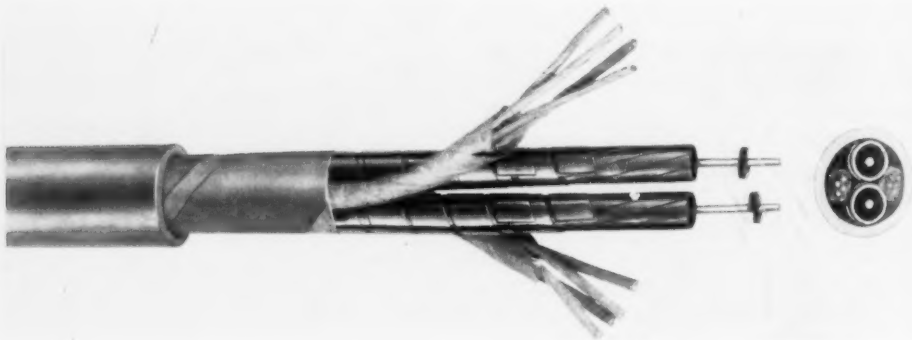


FIG. 10. COAXIAL CABLE WHICH WILL CARRY HUNDREDS OF MESSAGES

ON A SINGLE WIRE, AND ITS SURROUNDING COPPER TUBE. THIS TYPE OF CABLE WILL ALSO CARRY TELEVISION SIGNALS.

tion was extended from New York to Denver, Colorado, in 1911. But here again attenuation won temporarily, and satisfactory telephony, over distances greater than 2,000 lines, was impractical at that time.

Vacuum Tube Repeater

Then the vacuum tube, which had recently been discovered and with which we are familiar in radio sets, showed the way to the next advance. By using it to amplify the attenuated voice currents in "repeater" amplifiers at intervals, from 150 to 200 miles along the line, much as faint radio signals are amplified for the loud speaker, it was possible to bridge the gap between Denver and the west coast and on January 15, 1915, Alexander Graham Bell at New York spoke again over the telephone to his former assistant, Thomas A. Watson, at San Francisco. A group of these tubes is shown in Fig. 8. Those at the left are largely used at the present time. The ones at the right are a recent development with increased life. Either type lasts many thousands of hours on 24-hour service.

The next step was to project the voice over the ocean by radio. In 1915 words from the radio station at Arlington, Virginia, were heard at the Eiffel Tower in Paris, but it was not until 1927 that two-way commercial telephone conversation was established across the Atlantic Ocean. Now it is possible to sit at one's telephone and literally call the far corners of the earth.

Carrier Telephony

The vacuum tube amplifier not only made it possible to carry telephone messages around the world, but it also opened the way for a more efficient use of existing telephone lines by providing means for sending more than one message over a single pair of wires. This was possible because the vacuum tube can produce very constant frequencies of many thousands of vibrations per second which are much too high to be heard by the ear. By a method known as modulation these high frequencies can be made to act as carriers of ordinary telephone voice currents and by using a series of carriers of different frequencies several messages can be sent at the same time over the same wire, much as many radio broadcasting programs are carried simultaneously by the ether. At the receiving end these messages can be unscrambled and each one applied to its own telephone set by a procedure like that of tuning in a station with a radio receiving set. This

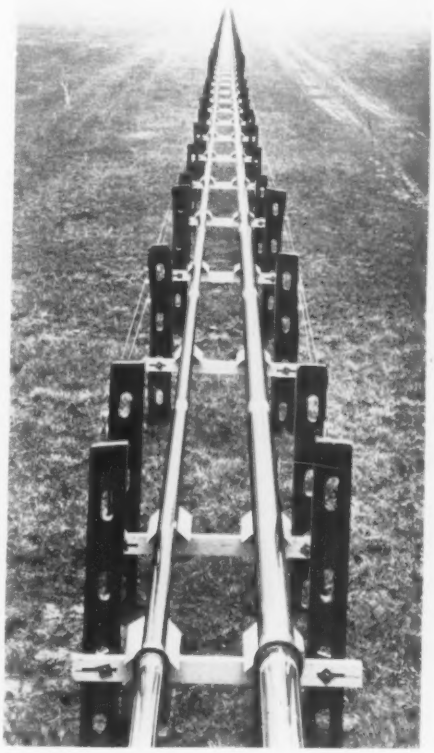


FIG. 12. EXPERIMENTAL CABLES

ULTRA-HIGH FREQUENCY EXPERIMENTS. BEYOND THE RANGE NOW USED IN TELEPHONY AND RADIO IS A REGION OF EXTREMELY HIGH FREQUENCIES NOW BEING INVESTIGATED WITH A VIEW TO FUTURE USEFULNESS IN COMMUNICATION SYSTEMS.

FIG. 14. AN AISLE OF A CENTRAL OFFICE IN A DIAL SWITCHING AREA SHOWING COMPLEXITY OF MODERN TELEPHONY.

method is shown schematically in Fig. 9, which pictures the arrangement now used on open wire telephone lines.

With this system one wire carries in addition to the ordinary telephone message at voice frequencies of from 200 to 3,000 vibrations per second two carrier telephone groups which cover the range from 6,000 to 140,000 vibrations per second. There is no fundamental difference in behavior between the two carrier groups. Type C was developed first and carries three messages. Later it was found that the J type circuits with twelve additional messages could be added by using higher frequencies. Sixteen telephone conversations and two telegraph massages can be carried thus over a single pair of wires. Each telephone has its own modulator M to combine the outgoing message with its high frequency carrier current and a demodulator D to separate the incoming message from its carrier. The message for each telephone is segregated from the rest by electrical filters F. Many transcontinental circuits are now operated on this principle. There is a practical limit, however, to the number of messages that an ordinary telephone line can be made to carry because the crosstalk into other pairs of wires strung on the same pole line becomes too great as higher and higher frequencies are used to carry more messages.

Coaxial Cable

At this stage transmission engineers again came to the rescue by devising the coaxial cable shown in Fig. 10. Instead of having two wires like an ordinary telephone circuit, this one has a central wire surrounded by a metal tube. The central wire is supported on insulating discs. Conductors of this type will carry frequencies of several million vibrations per second without crosstalking into each other and thus a whole new range of carrier currents became available for carrying telephone messages.

An experimental coaxial cable recently installed between New York and Philadelphia will carry 240 telephone messages simultaneously and uses frequencies up to over a million cycles per second. This is accomplished by using 240 carrier currents which occupy a range in frequency from 60,000 to 1,020,000 vibrations per second. The arrangement is shown schematically in Fig. 11. A separate coaxial conductor is used for sending and receiving and repeater amplifiers especially designed to carry high frequencies are located at intervals along the lines to restore the attenuated currents. In more recent experiments it has been possible to increase the frequencies to 2,000,000 vibrations per second and send 480 messages over this cable. The first commercial installation of coaxial cable is now operating between Stevens Point, Wisconsin, and Minneapolis, Minnesota, a distance of about 200 miles. This cable is capable of

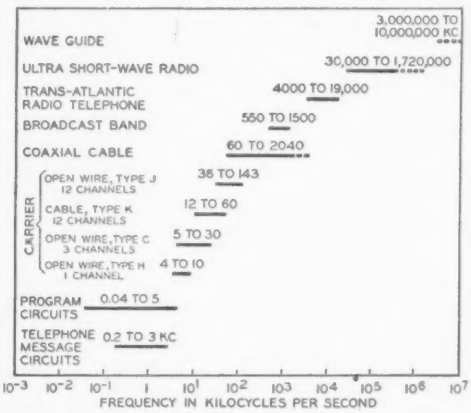


FIG. 13. GAMUT OF FREQUENCIES

NOW USED OR BEING INVESTIGATED FOR COMMUNICATION SYSTEMS EXTENDS FROM TWO HUNDRED TO THREE BILLION VIBRATIONS PER SECOND. THIS RANGE INCLUDES THE VOICE FREQUENCY OF LOCAL TELEPHONE CIRCUITS, HIGH FREQUENCY CARRIER CURRENTS USED IN LONG DISTANT TELEPHONY, AND THE STILL MORE RAPID VIBRATIONS OF RADIO COMMUNICATION.

carrying 480 messages. Coaxial cables can also carry television signals.

Ultra-High Frequencies

Beyond the frequency range now used on coaxial cables there is a region of still higher frequencies, extending from three to ten billion cycles per second, which is now being investigated. Brass tubes, illustrated in Fig. 12, are used to transmit these enormously high frequencies. As yet this region is entirely experimental, but the trend toward the use of higher frequencies in telephone communication has recently been so marked that these new explorations may soon find application in practical telephony. The gamut of frequencies now used or being investigated for communication systems is shown in Fig. 13.

In this brief outline only a few of the high-lights in the history of telephony have been noted, but these may serve to emphasize some of the great advances which have been made in telephone apparatus and methods since the first feeble messages were sent by Alexander Graham Bell over a two-mile span between Boston and Cambridgeport, Massachusetts, sixty years ago; and there is every reason to assume that further improvements will be made, for research and development engineers are continuously striving to perfect and extend our facilities for projecting the human voice instantaneously over great distances.

GENERAL EDUCATION AND SOCIAL PROBLEMS

Since its beginning in 1933 there has been considerable development in the conception of the purposes and scope of the Board's program in general education. At that time it was thought of as largely internal to formal education. That is, the Board's work was to be limited almost entirely to aid to study and experimentation with the academic curricula of the secondary school and the junior division of the college. Vocational education was definitely ruled out. True, the Board expected the American Youth Commission to consider the broad problem of the care and education of youth and to make general recommendations; but it was supposed that most of the projects aided by the Board would fall within the sphere of curriculum experimentation, and the development of new instructional materials and methods suited to the changing social scene and the changing secondary school population. It was tacitly assumed that the economic depression of 1929–1933 would soon be over, and thus there was no need for concern with the problems of youth employment.

But as the American Youth Commission and other organizations pursued their studies, it became evident that their task was more complex than had at first been imagined. Instead of restricting themselves to formal education, these groups found it necessary to consider the entire problem of the care and education of youth. Education was still the focus of attention, but the focus was widened to take in the social scene that gave rise to the need for a reorganized general education. It became clear that the task of these organizations was to help make America's provision for the care and education of youth keep step with the major social changes in which the country was engaged. Not the ideas of educational theorists about the nature of general education, but the hard facts of population trends, youth employment and government fiscal policy became the landmarks for charting the course. When it became clear that getting and keeping a job was the major problem of youth, the General Education Board indicated an interest in the field of vocational education by supporting projects dealing with the occupational adjustment of youth. When it seemed probable that the government would have to provide work or scholarships for large numbers of young people for ten years or more, the Board supported studies and experiments in connection with the government youth services.—*Annual Report of the General Education Board, 1940.*

THE AGING PROCESS AND TISSUE RESISTANCE[1]

By Dr. WM. deB. MacNIDER

KENAN RESEARCH PROFESSOR OF PHARMACOLOGY, MEDICAL SCHOOL OF THE UNIVERSITY OF NORTH CAROLINA

In connection with this discussion the observation is made to the effect that many biological scientists and physicians have been and are interested in embryonic life, the life of infancy and childhood and that changing and adjusting life of puberty, and yet relatively few individuals have shown the same degree of interest in the changing life of the middle-aged as it advances into senility, and finally to a senile and perhaps physiological death. It is appropriate as a contradiction to make this statement at Ann Arbor, as one feels the great, living influence of Warthin,[2] who through his monograph on "Old Age" not only made scientific and philosophical contributions of lasting worth, but stimulated interest to be expressed by research in this domain of biology as it touches all living creatures. Such an interest culminating in an understanding of the physical and chemical changes associated with the aging process is of more importance and offers greater difficulties than an understanding of similar changes in infancy and in childhood. In these age periods the life urge is for the normal and towards survival, while with later age periods the tendency is the reverse. The processes responsible for physiological life are on the wane. The time has come for chemical changes leading to degeneration and retrogression to supervene and slow down cell life until it closes.

An interest in the aging process is at least two-fold. Of fundamental biochemical importance is an understanding of what constitutes aging. What are the chemical differences developing with aging which tend to differentiate it from youth? If we know the significant facts in this domain of life we would also know something of a chemical nature which characterizes physiological life. Infancy and youth, the aged and the senile, represent chemical equations in a progressive adventure from life into death. From an applied point of view such understanding is of great importance. This order of knowledge would not necessarily prolong the senile state as such; perhaps this is not advisable, but it would very likely indicate how degenerative changes in tissues assumed to be normal for the aging individual could be modified or deferred, allowing the individual to live longer in this period of his life span in a more effective and happier fashion. It does not with fine sentiment assume "The best is yet to be, the last of life for which the first was made." It does something about it and in the doing may give life and joy to the fine lines of Browning.

As is so frequently the case in experimental work, one's interest becomes deflected away from the major emphasis of a planned experiment by some observation which at first would appear of incidental importance.[3] Many years ago experiments were undertaken in my laboratory in an attempt to explain various changes in urine formation when the kid-

[1] The second of a series of three articles on "Tissue Susceptibility and Resistance" contributed by the author.

[2] Alfred Scott Warthin, "Old Age." Paul B. Hober, Inc., 1929.

[3] Wm. deB. MacNider, *Jour. Pharm. and Exp. Therap.*, 4: 491, 1913.

neys were injured by a variety of chemical substances such as cantharidin, potassium dichromate, uranium nitrate and bichloride of mercury.[4, 5, 6] The physiological aspects of these experiments had to be done under the influence of a general anesthetic. The two generally employed substances for this purpose at this time were chloroform or ether. Very early in these experiments the observation was made that in so far as kidney function was concerned, chloroform exerted a much more inhibitory influence than ether. Not infrequently the use of chloroform as an anesthetic for from four to ten minutes would permanently arrest urine formation, while a similar influence from ether, when administered over a much longer period to dogs with an acute uranium nephritis, would only result in a reduction in urine formation. A further analysis of the toxic action of these general anesthetics for the kidney, established definitely that the degree of action was associated with the age of the animal.[7] A large percentage of the adult dogs, and with few exceptions those animals over eight years of age, became anuric when chloroform was used. In puppies, animals of seven months and younger, this influence was less marked or failed to occur. The age factor expressed itself when ether was employed by only certain of the older and senile animals showing an inhibition in urine formation. As a result of these observations it became necessary to analyze the data obtained in the animals of different age groups from the use of uranium as a renal poison before the employment of an anesthetic. This analysis indicated not only an increase in the susceptibility of the kidney in a structural sense to the action of uranium as these animals advanced in their life spans, but indicated changes of a quantitative metabolic order in the animals which were associated with the same factor. The puppies and young dogs showed only slight evidence of the toxic action of this chemical when given in the amount of two milligrams per kilogram, while the same dosage of the substance in adult and in senile animals, regardless of the weight of the animal, gave evidence of an intensification of not only the local renal influence, but of the generalized metabolic disturbance. The earliest of these changes consisted in the animals developing a glycosuria with the appearance of ketone bodies in the urine. Within six to ten hours there occurred a reduction in the reserve alkali of the blood. This is not a retention phenomenon due to a renal injury. It develops usually before the appearance of albumin in the urine and at a time when the elimination of phenolsulphonephthalein by the kidney is of a normal percentage. There is no retention of urea or non-protein nitrogen.

The explanation of the local toxic action of uranium for the kidney of animals of different age periods, as well as that of the more generalized tissue influence, is hypothetical. The influence of age is the determining factor for the degree of local injury and quantitatively for the influence of the chemical on metabolism. We may be permitted to assume that these changes are due to uranium inhibiting processes of oxidation. The degree of inhibition as evidenced quantitatively by the changes in the blood and urine become more marked as the animals advance in years and reach their height in certain of the animals as senility develops. The same order of disturbance may be obtained in young adult dogs and in puppies. Such changes are delayed in their appearance, are less marked and not infrequently in this group of young animals there occurs

[4] *Idem, Jour. Med. Research*, 21: 79, 1912.

[5] *Idem, Jour. Med. Research*, 23: 403, 1913.

[6] *Idem, Proc. Soc. Exp. Biol. and Med.*, 11: 159, 1914.

[7] *Idem, Jour. Pharm. and Exp. Therap.*, 17: 289, 1921.

no change in one of the fundamental equilibria of the organism, the acid-base balance of the blood. Just the reverse status is found to occur, especially in the senile animals, and also in normal animals under the strain of pregnancy.[8] Such normal animals, even in advanced senility, have the ability to maintain this balance, but when placed under a strain to maintain it, either by the use of uranium or a general anesthetic, its instability is shown by the rate and the degree to which the reserve alkali is depleted.

From the kidney and the liver of these animals of different age groups biopsy material was obtained to investigate the type of change developing in these organs as influenced by the age factor. Such tissue from the kidneys of puppies shows but slight histological evidence of injury. There is no evidence of glomerular injury. The amount of stainable lipoid material in the ascending limb of Henle's loop in which location of the tubule such material is normally present, is increased in amount appearing as fused, coarse granules. The proximal convoluted segment of the tubule, on account of the selective action of uranium in this location gives more evidence of injury. Small amounts of lipoid material can be demonstrated in these cells. It does not occur here normally. The epithelium shows cloudy swelling, the cytoplasm is granular and rarely vacuolated. The nuclei of such cells usually stain in a normal manner. In the adult, aged and certain of the senile dogs these histological changes are intensified. The two most conspicuous changes are the increase in the amount of stainable lipoid material in the epithelium and the ability of such cells to take up and bind water with the development of a marked degree of vacuolation. The question again arises for the localized cellular changes in the kidney as expressed quantitatively through the age factor if they may not be due to uranium inhibiting changes of oxidation within such cells, the effect of the inhibition having a greater physical expression in the cells of aged animals than in young animals and puppies. These experiments have been recounted in order to indicate that aging as such, whatever this may compositely mean, may so influence an organism as a whole, and specifically one or more organs of such an animal as to greatly modify quantitatively the action of a chemical of known composition. There is no reason not to consider that the utilization of food materials may be subjected to similar influences dependent basically on the age of an animal and that the same type of reasoning should not be applied to the value of the various vitamins in such age periods. It may well be that certain of the tissue degenerations of the middle-aged are due to a combination in a state of imbalance of these two factors.

The histological studies which have been discussed were employed in an attempt to explain the increasing toxic effect of both chloroform and ether for the kidneys of dogs rendered acutely nephritic by uranium as such animals advanced in their life span. These studies indicate that other than the usual changes of degeneration which injurious chemical substances induce in the kidney, the characteristic change which is quantitatively associated with the aging process is the amount of stainable lipoid material in terms of an increase which makes its appearance in the epithelium following a uranium intoxication. The presence of this substance in a fashion sinsetizes the epithelial tissue of the kidney for the toxic effect of these general anesthetics. Its presence is likely the chemical factor which enables the kidney of the animals as they advance in age to bind such an amount of the anesthetic body that it expresses itself structurally by both an increase in the amount of stainable lipoid and by

[8] *Idem, Jour. Exp. Med.*, 43: 53, 1926.

the development of an acute necrosis of the cells of the convoluted tubules. There is no evidence of structural alteration in the glomeruli other than an increase in lipoid material. In the light of these observations the question arose as to whether or not the toxicity of these two general anesthetics for the kidney might not be influenced by employing agents prior to the anesthesia which would lessen the amount of stainable lipoid material in the kidney and in this manner decrease the amount of the anesthetic body which would be taken up, transitorily bound by such tissue and enabled to manifest its toxic effect by renal epithelial degeneration. For this purpose two different substances have been employed; a solution of sodium carbonate equimolecular with 2 per cent. sodium chloride, or a 20 per cent. solution of glucose, the usability of which was facilitated by employing insulin subcutaneously. For purposes of control, animals of the same age periods as those receiving either the sodium carbonate solution or the glucose were given a 0.9 per cent. solution of sodium chloride. Six hours after the use of such solutions biopsy material was obtained from the kidneys of the animals in order to ascertain by microchemical methods the amount and distribution of stainable lipoid material in this tissue from animals of different age periods that had been rendered acutely nephritic by uranium. In the control group of animals the use of sodium chloride solution had no effect in modifying the amount of stainable lipoid material developing in the kidney of the animals of the different age groups from the use of uranium. It failed to give the kidney any protection against the subsequent use of the general anesthetics. The use of glucose with insulin was variable in its effect. In the young adult animals it not only manifested its diuretic action, but in such animals its use led to an apparent decrease in the amount of stainable lipoid, especially that which develops in the convoluted tubules. Such animals were afforded a degree of protection against the use of ether as an anesthetic but no definite protection against chloroform. The most definite evidence of renal epithelial protection was obtained when a solution of sodium carbonate was used before the period of anesthesia. Such a solution when given to puppies and young adult animals so changes the chemical constitution of stainable lipoid material in such cells that it fails to give the characteristic staining reaction with Scharlach R. This is true to a less extent for animals over eight years in age so that when dogs in these different age groups are anesthetized by ether all are found to remain diuretic and responsive to diuretic substances. When chloroform is employed there is less evidence of protection for the older animals. They do not become anuric, as is invariably the case when they are anesthetized with chloroform without the protection from the carbonate. In general the use of this substance in adult animals, and in a certain proportion of the old and senile animals, translates them in so far as their renal toxic response to the anesthetic is concerned to the status of much younger animals.

In an earlier part of this discussion the statement was made that certain of the senile animals failed to show an accumulation of lipoid material in renal tissue, especially in the epithelium following the use of uranium nitrate. Such cells in animals of this age period were refractory to this chemical influence. Associated with this difference in the pathological chemical constitution of such cells, this tissue failed to show evidence of rapid injury characterized by necrosis from the use of the general anesthetics. This observation would strengthen the inference which has been

made that the presence of such material is the chemical factor which determines the affinity of the anesthetic for renal tissue, in turn determines its concentration, and through this concentration enables the anesthetic body to induce changes of degeneration. The morphology of the epithelium in the proximal segment of the convoluted tubule of these senile animals which show an absence of stainable lipoid material, following the use of uranium, and which resists the toxic action of the anesthetic substances, is not of a normal order. The cells lining such tubules are atypical, flattened structures, or the lining is of a syncytial nature resembling in structural configuration the type of cell described in the first lecture as developing in the liver or the kidney[9] from the use of uranium and which imparted to such epithelium an acquired resistance against not only uranium, but to other chemical substances of a very different order. For the senile animals under discussion the acquisition of this atypical type of cell was not brought about by any experimental procedure in which a chemical body was employed to injure cells and lead to a process of repair. Whether or not this change in cell type arose as a repair process, the result of intercurrent renal disease of an unknown nature, or whether in a certain percentage of aging animals this change develops as a structural part of the aging process is not known.

For a number of years routine histological studies have been made by obtaining biopsy material or material at autopsy from both the liver and the kidney of dogs over five years of age that have come through the laboratory for either experimental or routine teaching purposes. Such tissues from one hundred and eleven animals falling in this advancing age category have been available for study. Of this number the livers of eighteen of the animals have shown the type of changed epithelium which has been described for the kidney of these and of other animals. Fourteen of these aged animals which have shown this naturally acquired shift in the epithelial structure of the liver have been starved for twenty-four hours and then given chloroform by inhalation for three hours without the development of a central necrosis of the liver lobules. At a later period, when the same animals were starved for forty-eight hours and given chloroform on two successive days, evidence of injury as a partial necrosis developed in this location of the lobules. Such results are in striking contrast to those recounted in the previous lecture in which, after a period of starvation, this anesthetic was administered to dogs with a normal epithelial structure, but resembles the results obtained when chloroform was given to animals which had been intoxicated by uranium and had repaired the liver injury by the formation of an atypical and resistant type of epithelial tissue.[10]

[9] *Idem, Jour. Exp. Med.*, 49: 411, 1929.

Summary

1. The observations which have been presented in this discussion indicate that the quantitative response of an animal organism to the influence of a chemical substance may in large measure be determined by the age of the organism, and furthermore, that this factor of age may show itself in a structural manner by either facilitating or in part preventing changes of a degenerative nature from developing in such tissues.

2. An attempt, or perhaps better, a suggestion has been offered without adequate and substantiating proof to explain these generalized and localized differences in the action of one substance, uranium nitrate. The explanation concerns itself with the quantita-

[10] *Idem, Jour. Pharm. and Exp. Therap.*, 56: 383, 1936.

tive ability of this substance to inhibit processes of cellular oxidation. This action would vary in animals of different age periods. As the animals advance in their life span this evidence of an inhibition of tissue oxidations increases, as is shown by the degree of glycosuria, the extent to which ketone bodies are formed, and appear in the blood and urine, and finally by the ease and degree to which a reduction in the reserve alkali of the blood may be obtained.

This concept of an inhibition of intracellular processes of oxidation by uranium nitrate would assume that as the animal ages these intracellular life processes diminish so that in an aged or senile animal the same degree of oxidative inhibition induced by uranium nitrate would have a more marked chemical expression than it would have in a younger animal in which these processes for life take place in a more abundant manner and in a more completed manner.

The significant localized cellular changes of a histological order which occur during such a process of oxidative inhibition are shown by the accumulation of stainable lipoid material in the epithelial tissue of the liver and kidney and by an increased binding power of such tissue for water. Associated with the degree to which stainable lipoid material accumulates in such cells there exists a definite relationship with the ability of two other chemical substances, ether and chloroform, to exert their local toxic effect for these organs. There is no reason not to suppose that these anesthetic bodies may exert not a toxic action, as expressed by degeneration, but an anesthetic influence on these structures when they become sinsetized for this action by lipoid accumulation. In puppies or in young adult animals in which the use of uranium leads to the least accumulation of this substance, the anesthetics have their minimum toxic effect, while, as the animals advance in age, with an increase in such intracellular material, the same anesthetics not only acquire the ability to arrest function as anesthesia, but demonstrate an exaggeration in their ability to induce structural changes of a degenerative order.

These studies have furthermore shown that the use of an alkali which indicates its intracellular influence at least in one gross manner, by changing the staining reaction of lipoid material, has associated with such a modification of this material the ability to afford protection to both renal and hepatic tissue against the toxic action of ether and chloroform. Finally, associated with the aging process there may develop in certain senile animals a change in the morphology of hepatic epithelium from that of a polygonal type of cell to one of a flattened order which fails to show the presence of stainable lipoid material. Such cells are resistant, not only to uranium, but to ether and chloroform.

3. These investigations have demonstrated that not only may cell morphology change as animals age, but that with or without such changes the chemical nature of the cell may vary. Chemical reactions within an organism may be modified by processes natural for the animal as well as by the introduction of chemical substances not of a natural order for such tissues. These observations tend to lead one away from a consideration of form as such, and to stimulate an understanding of the chemical nature of form as influenced by aging. In the future this type of investigation may furnish for the aging and the senile individual a competent group of applied biological scientists as physicians who will attempt through their understanding to in part prevent or delay tissue degenerations now considered normal for the aged, and enable individuals in these advancing age groups to live more effective, more related and happier lives.

PHYSICAL THERAPY

By Dr. RICHARD KOVÁCS

NEW YORK, N. Y.

THE story of the gradual evolution of the therapeutic employment of physical forces of nature makes fascinating reading. In many instances the genius of one keen observer—not necessarily a physician—recognized the beneficial effects of such procedures as water treatment, electricity in some form, sunlight or a certain manipulation or exercise. In enthusiastic hands, at first the healing virtues of such a new method are magnified, while failures are disregarded and the method often "runs wild." The medical profession, being conservative as a whole, wants proof of success obtained under its scrutinizing observation; for this reason only such measures become adopted that have stood extensive trial in critical hands.

A spectacular development in the treatment of disease and injury by physical methods has come about only during the past twenty-five years in the United States. Up to the time of the first World War the few medical men actively practicing physical therapy were looked upon by the majority of their colleagues with suspicion, mingled with pity. Scattered groups of enthusiasts practiced electrotherapy in one corner, hydrotherapy in another, and manipulation and massage in still another corner. There were no physical therapy departments in hospitals where the different physical methods could be correlated. Clinical and laboratory research could not be done, and the scrutinizing eye of the medical profession could not keep an institutional check on the results with these new methods of the healing art.

A change for the better came when, as a result of the World War, thousands of disabled men had to be put back into a state of comfort and functional activity. It became recognized, chiefly through information imported from abroad, that well-equipped and conducted physical therapy departments are indispensable for this purpose, as adjuncts to orthodox medicine and surgery. Concurrently, development of many new and highly effective methods of physical treatment, such as diathermy, and artificial ultraviolet radiation took place. Within a few years there became available a large body of technicians trained in physical therapy and a good number of medical men capable of practicing it. But above all, the majority of medical men became convinced that the practice of physical therapy must become part of the standard practice of medicine.

Dean Torald Sollmann, professor of pharmacology of the School of Medicine of Western Reserve University, stated recently:

> . . . although drug therapy and drugless therapy may seem direct antipodes to the superficial thinker, they involve the same principles, evoke the same phenomena, accomplish the same results. They differ only in the means which they employ, of which sometimes the one, sometimes the other is better adapted to secure the desired end. Indeed, the differences between physical therapy and pharmaco-chemical therapy are no greater than those between radiant and direct heat, or between local and general anesthetics.

Drug therapy employs medicinal remedies which are administered through the stomach or intestines or by inhalation or by injection under the skin or in a vein; these remedies exert a therapeutic effect by stimulating or depressing certain functions of the body. Physical therapy generally employs remedial agents which primarily affect the skin

and the underlying soft tissues and in turn act on local or general circulation, on the nervous system or on other body organs or systems; at other times physical therapy consists in employing the body's own vital forces as in the form of regulated exercise. The obvious advantages of physical measures are that they usually can be directly applied to the affected part and often give immediate relief in acute conditions. In chronic conditions patient and systematic application is essential, but there is no danger of habit forming as in the case of the use of certain drugs.

Thermotherapy

Heat is the most frequently used and most versatile among physical treatment forces. Since the beginning of man's history hot springs were the meccas of sufferers from rheumatic and other disabling conditions. Modern technical progress has placed at the disposal of physicians and the laity a bewildering number of thermal measures. Conductive heat is supplied by hot-water bottles, electric and other heating pads, hot compresses, hot-water and hot-paraffin baths, but the penetrating effect is very limited; with surface heating which can be safely tolerated, the deep-lying tissues dissipate heat at a faster rate than it can be conducted to them. Radiant heat is applied by heat lamps, consisting of incandescent lamps placed in a reflector and nonluminous heating elements, warmed up to just a dull red heat; the high temperature radiation from heat lamps penetrates deeply through skin layers and even into the subcutaneous fat and muscles, while the low temperature glow heat is all absorbed in the superficial layer of the skin. Conversive heating consists of a passage of a large amount of a high frequency electrical current deeply through the tissues, as will be discussed later on under diathermy.

The various forms of therapeutic heating are employed either to part of the body or to the body as a whole. The immediate effect of any form of heating is a rise of temperature in the body tissues; in relation to the degree and extent of heating there follows as a reaction by the heat-regulating mechanism of the body an increase of circulation and with this an increased local metabolism. This is most useful in assisting nature in the resorption of products of injury and inflammatory reaction. It also aids the forces of defense against infection by increasing the activity of the white blood corpuscles and increasing local immunity of tissues. The most important heat-sensitive organism, the gonococcus, can be directly killed in the tissues of the body by a temperature of 106.7° F. which is within physiological tolerance of the tissues, provided that this temperature is maintained at the thermal death time varying from six to twenty hours according to the particular strain of gonococcus. Mild heating on the other hand is also one of the oldest means to relieve irritation of sensory nerves—pain, and of motor nerves—spasms and cramps. The most likely explanation of the pain-relieving effect is an inhibition through the temperature nerves of the skin.

Therapeutic heating locally applied is one of the most frequently used measures in treatment of traumatic, inflammatory and rheumatic affections. It is evident that in any case the type and extent of heating must be skilfully selected and directed. When there is heat there may be burns; there is no entirely safe form of therapeutic heating. Artificial fever has been found effective in a variety of conditions resistant to routine medical treatment, among them advanced forms of organic nervous diseases, such as general paralysis of the insane and locomotor ataxia, gonorrheal arthritis and gonorrheal inflammations of the female and male organs, chorea minor and certain forms of bronchial asthma.

Light Therapy

Sunlight represents a blending of infrared, luminous and ultraviolet radiation. In the average sunlight there is about 60 per cent. infrared or heat radiation and 40 per cent. visible and ultraviolet radiation; all these from a physical standpoint represent electromagnetic radiations of different wave-lengths. The ultraviolet part of sunlight has received considerable attention in recent years, but it must not be forgotten that if the heat rays of the sun were screened off the earth, it would be surrounded by an ice crust in short order; and if it should cease to send the green portion of the visible spectrum, which is responsible for the formation of chlorophyl—all-important for vegetable life—all life on earth would become extinct.

Ultraviolet radiation by itself exerts chemical effects on the skin, resulting in the activation of vitamin D, which in turn influences calcium and phosphorus metabolism and acts as a preventive of rickets and other calcium deficiency conditions; it also makes general metabolism more efficient, causing the organism to operate with increased economy; there seems to exist also a stimulating effect on the endocrine glands. The effects of sunlight and its artificial substitutes in the form of mercury vapor and carbon arc lamps for improving appetite and sleep, increasing assimilation and metabolism are extensively utilized in therapeutics.

The bactericidal effects of ultraviolet radiation on germ life have been recently employed for "air sterilization" in keeping the bacterial contents of operating rooms and children's wards at a minimum. In the tissues of the human body bactericidal effects are limited to the uppermost layers of the skin because ultraviolet penetrates only to a depth of two millimeters. However, in treatment of sluggish and infected wounds and some skin infections, such as erysipelas, ultraviolet rays, especially when combined with heat radiation, are quite effective.

The curative effects of heliotherapy on tuberculosis of the bones, joints and lymph glands and other forms of "surgical" tuberculosis are without a generally accepted explanation. The rest, climate, general hygiene in heliotherapy establishments undoubtedly also play an important role, as proven by the fact that simple lamp treatment can not duplicate the results. Self-prescribed and self-administered ultraviolet lamp treatments as fostered by commercial interests carry with them dangers of over-exposure and of careless handling.

Electrotherapy

Electricity for treatment is employed in the form of electromedical currents such as the galvanic, faradic, sinusoidal and high frequency, which are practically all derived from the commercial lighting current by changing it by a variety of devices. According to their strength, volume and frequency these currents affect body tissues on the surface or interior of the body. All effects of electricity can be satisfactorily explained on the basis of physics, chemistry and physiology.

The oldest form of therapeutic current is the galvanic, which corresponds with the commercial "direct" current. When applied to the body this current exerts mild stimulation through chemical action: an acid effect by the positive pole and an alkaline by the negative pole. Medical ionization by the galvanic current is based on the elementary law of electro-physics, that bodies with unlike electric charge attract each other while those with like charges repel each other; consequently, medicinal substances can be introduced in "ionic" state into the skin or mucous membranes from a pole of opposite electric charge. Such treatment is being employed in treating

chronic inflammation in the ear, nose, genital tract with copper and zinc ionization and in treating some forms of arthritis and rheumatic conditions, and sluggish ulcers with vasodilating drugs which beneficially affects local blood circulation. Treatment of superfluous hair by destroying its roots by a needle charged with a galvanic current is popularly known as electrolysis.

If the galvanic current is employed instead of a steady flow in the form of a sudden interruption, the impact of electric ions causes stimulation of nerves and muscles. There exists a physiological time-intensity relation of electrical stimuli: in order to produce a contraction by ionic changes a current must have a certain minimal strength as well as a certain minimal duration. In electrotherapy the term of low frequency, or contractile currents, embraces all currents used for stimulation of muscles. When the existing muscle power can not be employed for voluntary exercise, or when the muscles are fully paralyzed, the problem is to maintain a minimum of muscle function until normal nerve impulse returns. Electrical muscle stimulation in skilled hands is valuable in after-treatment of injuries resulting in simple muscle weakness as well as in the long dreary months of recovery after a nerve injury or in infantile paralysis.

In the new method of electric shock therapy a low frequency current is applied through the brain; the mild shock to the nerve centers acts favorably in such mental disorders as schizophrenia. This development, replacing the more risky shock treatment by drugs with one controllable physical means, is similar to the introduction of electric fever in treatment of progressive paralysis and other disorders, replacing the more dangerous fever produced by malarial inoculation.

The most widespread use of electricity in treatment nowadays occurs in the form of high frequency currents. With electric currents consisting of electrical oscillations of several millions per second, produced by spark gap or radio tube apparatus, because of the extremely short duration of each single impulse there occurs no ionic movement. Consequently, high frequency currents do not excite muscle and nerve tissue; their oscillating energy is simply transformed into heat energy along the path of the current which can be employed at a much higher volume because of the absence of any shock. Medical diathermy denotes the use of a high frequency current for through and through heating of human tissues, while surgical diathermy or electrosurgery denotes the drying or destruction of diseased tissue or new growths on the surface or interior of the body by a suitable operative technic.

Two forms of medical diathermy have been developed; oscillations of about one million frequency are employed with metal electrodes directly applied to the skin and are known as long-wave diathermy; while oscillations of a frequency of ten millions or more can be employed with the electrodes an inch or more apart from the skin and are known as short-wave diathermy. There is no particular difference between the clinical effects of long- and short-wave diathermy, notwithstanding some enthusiastic assertions of the protagonists of the newer method of short-wave diathermy. Both act primarily as tissue-warming agents and are principally useful in deep-seated chronic inflammatory conditions of joints, bones and inner organs, when used in conjunction with other indicated medical routine. Short-wave diathermy can be more easily employed in acute sinus inflammation and pus infections of the skin because of avoidance of skin contact by the electrodes. On the other hand, in such conditions mild doses of radiant heating appear equally useful and much simpler. The dosage of diathermy and consequently the rise of temperature in

the deep tissues is largely guided by the operator's clinical experience and the patient's comfortable skin sensation; so-called dosimeters for short-wave diathermy have been constructed, but have found as yet no general clinical acceptance.

Electrosurgery by high frequency electricity has opened up a new vista in the surgery of such highly vascular organs as the brain, spleen; the instantaneous coagulation of the contents of numerous small blood vessels and capillaries under an electrically charged instrument enables operations with a minimum of bleeding and under perfect control. With these new developments medical electricity, once a much abused stepchild in therapeutics, has become now an agent of everyday use in physicians' offices and hospitals.

Hydrotherapy

Water in its employment as a physical therapeutic measure depends on its property as a medium for conveying of certain physical forces. Water has a great capacity for absorbing heat; and it can readily be applied with varying and regulated pressure. Hence the two main divisions of treatment of water are hydrothermal applications, in which the temperature effects of the water play the leading role, and hydrokinetic applications in which the mechanical effects of immersion, of the pressure and flow of water exert, in addition, certain specific effects. There occur also a limited amount of hydrochemical effects by the introduction of certain skin-stimulating substances.

Water applied to the body at a temperature different from that of the average skin surface—92° F.—either will conduct heat to the body or absorb heat from it. The difference in temperature acts as a "stimulus" or irritation of the nerve endings of the skin. The more intense the stimulus, the larger surface of the skin it affects and the longer it lasts, the more intense will be the reaction caused by it. Tepid water, at a temperature of 92° to 94° F., causes no external stimulation of the skin nerves and therefore exerts a marked relaxing, nerve-resting effect upon the entire body. One can lie in such a bath for hours in perfect repose. Hence its time-honored application in the calming treatment of disturbed patients in mental hospitals, avoiding narcotic drugs or mechanical restraint.

A short cold application causes constriction of the blood vessels of the skin and of the muscular tissues underneath it, also a deep inhalation—the familiar gasping and other effects on the circulation—slowing of the pulse, increase of the tone of the heart muscle. This cold "reaction" is used in many general cold-water applications—ablutions, baths, showers—to stimulate the vital forces of the body. A cold compress applied to a small part of the body and frequently renewed serves for immediate relief in recent injuries as well as in early stages of inflammation, by combating swelling and pain by constriction of the blood vessels of the skin. Cold wet packs applied to the entire body are very effective in quieting restless, sleepless people, for after the initial cold reaction there occurs a dilation of the blood vessels of the skin and a relaxing effect of the warm vapor on the sensory nerve endings. The same effect explains the beneficial effect of so-called stimulating compresses which are cold compresses left on without change; they are locally helpful in acute congestive conditions of the throat, chest and abdomen. There exists a large variety of other forms of cold and hot applications, ablutions, sheet baths, partial baths, hip and sitz baths and contrast baths, all employed on the basis of definite physiological principles.

The paraffin bath is a newer form of

heat application consisting of immersing the hands or feet in melted paraffin, at an average temperature of 115° F. It offers a high degree of even surface heating and makes the skin soft and pliable, ready for subsequent massage or exercise. Such a combination treatment is especially effective in swelling and stiffness following injuries and infections. Carbon dioxide baths contain natural or artificial carbon dioxide gas administered in a bathtub with the water at a temperature of about 92° F. Such a bath causes a dilation of peripheral vessels of the skin and increases the output of the heart and the blood pressure; in skilled hands it is useful in chronic heart disease. These are just a few of the many other special forms of baths.

The hot whirlpool bath is nowadays the most extensively used hydromechanical measure. In it water at a temperature of about 110° F. is kept whirling by a motor or under its own pressure and thus exerts gentle friction to the skin in addition to the sustained heat; this is especially useful in relieving pain and stiffness after recent fractures and in circulatory disturbances of the extremities. Under-water exercise tanks and therapeutic pools make use of the old Archimedic principle that a body immersed in water is buoyed up by a force equal to the weight of the water it displaces; the elimination of the gravity effect enables muscles too weak to perform outside of water to be actively exercised; in addition, the heat of the water relaxes spastic muscles and improves circulation. This pool treatment opened up a new means for exercising weak muscles in infantile paralysis, also after injuries and in stiffness following arthritis. In outdoor pools the fresh air and sunshine add beneficial tonic effect on the entire body.

Colonic irrigations are used for mechanical cleansing purposes and have been brought to popular interest largely by commercial propaganda. Some of these "colon filling" establishments cater to a misled group of colon "addicts." In competent hands there is, however, some real merit to colonic irrigation in certain obstructive and toxic conditions of the lower bowel; it is now so employed, under adequate medical supervision, in many institutions of standing.

Spas and health resorts make use of water for drinking, bathing and for some of the treatment procedures just described. The present world crisis with the continued inability of patients to go abroad offers a favorable opportunity to promote many of the fine resorts in the United States. The American Medical Association has recently appointed a Committee on Health Resorts. Among the many obstacles, however, in the way of a more general utilization of American resorts are the lack of spa-mindedness by American physicians, the lack of interest of most state and municipal authorities and subsequent dearth of suitable surroundings and development, the lack of competent medical direction in many places, in others the high cost of spa treatment. Many chronic conditions and convalescence could be treated advantageously in our spas to a much larger extent than heretofore.

Mechanotherapy

Massage is one of the most simple and most useful forms of physical treatment, requiring only a pair of skilled hands directed by a trained brain. In massage the physical energy of the operator's hands is transmitted to the patient and there are a number of massage movements serving a variety of purposes. Gentle stroking is an almost instinctive motion to exert a sedative reflex effect for soothing of pain, while deep stroking in the direction of the venous and lymph circulations relieves engorged veins after injuries and promotes resorption of chronic inflammatory swellings. Com-

pression, kneading, hacking and tapping are effective in the most frequent object of local massage, of toning up muscles and freeing adherent parts; they exert a varying extent of mechanical stimulation of the skin, muscles and nerves. In stiffness and swelling, following injuries and rheumatic conditions, intelligent massage preceded by suitable heating is most beneficial. In convalescence and in many chronic disease conditions general massage helps to maintain the general well-being, muscle tone, appetite and sleep. There is much false propaganda about the value of massage in obesity. No amount of violent massage can break up or reduce it "in spots." Likewise "rubbing" by a husky bath attendant has very little relation to scientific massage, and the effectiveness of massage treatment depends by no means on the amount of physical effort expended.

Exercise or gymnastics imply the employment of one's own vital forces in contrast to massage and manipulation which utilize the energy of another person. Exercises administered for curative purposes are of two kinds: general exercises to improve the function of the entire body and its organs, or local exercises to improve the function of one part—such as a joint or a tendon. Occupational therapy is closely associated with physical therapy; it is based on the principle that, whenever possible, putting the patient to work at some interesting occupation is much more beneficial than if left to himself to do routine exercises.

Physical treatment methods are applicable in all departments of medicine and are finding employment nowadays by general practitioners and specialists alike. Physical therapy technicians, lay operators and cultists of all shades are also eager to exploit the newly awakened interest of the public. However, in order to derive the best results from any form of apparatus or from bathing or exercising, more is needed than the mere knowledge of how to turn on a switch or go through certain movements. Any physical measure to be applied must be based, first, on a correct diagnosis, implying a definite conception of the existing pathological and functional departures of the body from its normal state in health; secondly, there should be no doubt as to what physiological responses to expect from physical treatment and thirdly there must be a full knowledge of just how that treatment is to be rendered, and finally seasoned experience is needed how to choose among the variety of treatments and to judge the body's reactions thereto. Physical treatment must be as carefully prescribed and administered as any medicinal treatment, for any physical measure that is powerful enough to do good is just as likely to do harm if incorrectly applied. There can be no doubt nowadays that in competent hands in acute diseases physical treatment serves as a valuable aid to recovery, while in chronic disease it acts as the most important reliever of pain and often offers the only chance of restoration and a return to useful life.

OPTIMUM AGES FOR EMINENT LEADERSHIP

By Dr. HARVEY C. LEHMAN

PROFESSOR OF PSYCHOLOGY, OHIO UNIVERSITY

WHAT are the optimum ages for attaining outstanding leadership? What are the chronological ages at which leaders are most likely to reach the high points in their careers? Fruitful investigation of this topic entails the collection of data for specific types of leadership. Moreover, the findings will need to be expressed numerically. With these two facts in mind the writer has sought to ascertain: (1) The chronological ages at which men have most often attained recognized or nominal leadership in several fairly specific kinds of endeavor, and (2) the chronological ages during which such leadership has been most frequently exercised or retained. Although it would probably be futile to attempt to evaluate the services of the leaders within each of the age groups, it is nevertheless possible to determine the relative frequency with which members of the various age groups have acquired and exercised various types of nominal leadership.

In some instances the leader probably determines in large measure what his followers shall think and how they shall act. In other instances the "leader" may resemble the small boy who marches in front of a brass band, and who maintains his position of "leadership" merely by anticipating correctly the direction that the band will next take whether or not he continues to "lead." For example, it seems obvious that some political leaders follow, rather than mold, public opinion. It is probably true also that in some instances the nominal leader is not the real leader but merely the tool or the "front" of one or more schemers or pressure groups. Since the present writer knows of no satisfactory method for measuring the extent to which a leader has exercised genuine, in contrast to merely nominal, leadership no attempt has been made in this study to distinguish between these two kinds of leadership except in the case of military and naval leaders.

In practically all cases of nominal leadership the leader is chosen in recognition of his *previous achievement;* hence even without such data as will be presented in this article it would be a logical deduction that the ages of leadership will tend to occur later than the ages of individual achievement. In former studies (1) the writer has attempted to ascertain the chronological ages at which outstanding contributions are made. In some cases the obtained ages doubtless lag slightly behind the ages of actual achievement (*e.g.*, the publication of medical discoveries must occur after the discoveries are made). In the present study there is almost certain to be a much greater lag between the time of exihibiting the ability to lead and the attainment of eminent leadership, since eminent leadership is likely to result from a general group recognition of the ability to lead.

There are of course other factors than the lag of recognition behind achievement that prevent youthful leadership. But the slowness with which ability is recognized should forestall the hasty conclusion that the ability to lead necessarily develops when or after eminent leadership has been attained. For example, in the case of some of the presidents of the United States, their outstanding achievement in handling men

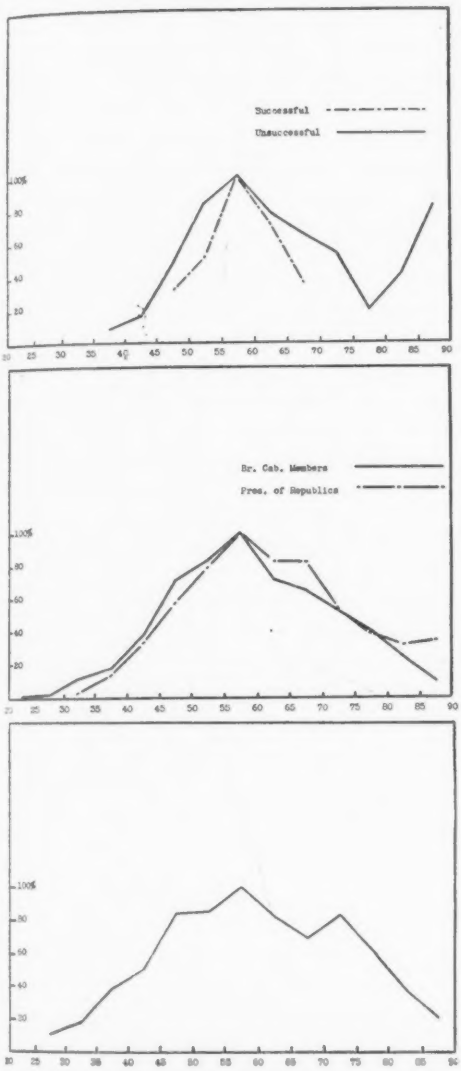


FIG. 1. AGES OF PRESIDENTS AND MINISTERS

Top: PRESIDENTIAL NOMINEES. (A) AGES AT WHICH 38 SUCCESSFUL PRESIDENTIAL CAMPAIGNS WERE MADE BY 27 DIFFERENT INDIVIDUALS, AND (B) AGES AT WHICH 108 UNSUCCESSFUL PRESIDENTIAL CAMPAIGNS WERE MADE BY 73 DIFFERENT INDIVIDUALS. *Middle:* (A) AGES AT WHICH 1,363 YEARS OF SERVICE WERE RENDERED BY 218 DECEASED MEMBERS OF BRITISH CABINETS, AND (B) THE AGES AT WHICH POLITICAL LEADERS SERVED AS PRESIDENTS OF THE VARIOUS REPUBLICS OF THE WORLD, OTHER THAN THE U.S.A., FROM APPROXIMATELY 1890 TO 1938, INCLUSIVE. *Bottom:* CHRONOLOGICAL AGES AT WHICH THE "CHIEF MINISTERS" OF ENGLAND SERVED FROM 920 TO 1720, AND THE AGES AT WHICH BRITISH PRIME MINISTERS HAVE SERVED SINCE 1721.

and situations may have occurred *before* they held the presidency and may have been the crucial factor that enabled them to attain the presidency. A record of actual ability to lead would be very interesting, but difficult to obtain. In the pages that follow, nominal leadership of the following kinds will be discussed in order, namely:

1. Political or governmental
2. Diplomatic
3. Military
4. Naval
5. Judicial
6. Professional
7. Religious
8. Educational
9. Business

Political Leaders

At what chronological ages are individuals most likely to reach the top of the political ladder? Fig. 1 (top) reveals the relative frequency with which men have been nominated for the presidency of the United States of America by the more important political parties. This figure is based on: (1) 38 successful presidential candidacies of 27 different nominees, and (2) 108 unsuccessful candidacies of 73 different nominees. In Fig. 1 (top) the broken line presents data for all successful candidacies down to and including the second term of Franklin D. Roosevelt, no distinction being made in this graph between first elections and second elections. The solid line of Fig. 1 (top) presents analogous information regarding the unsuccessful candidacies.

The reader should bear in mind that Fig. 1 (top) refers not to individuals but to the individuals' presidential candidacies. Obviously, the same man may have been a successful candidate in one or more elections but unsuccessful in others.

Although Franklin D. Roosevelt is usually listed as the 32nd president of the U. S., the broken line of Fig. 1 (top)

presents data for only 27 different individuals because Grover Cleveland was both the 22nd and the 24th president of the U. S., and four other individuals were not elected to the presidency but assumed it as vice-presidents on the deaths of their immediate predecessors. In Fig. 1 (top) the vice-presidents who became presidents only by reason of the deaths of their predecessors have been omitted because it was found that vice-presidents have been elected most frequently at ages 50 to 54 inclusive, whereas, presidents have been elected most often at an older age interval, namely, at ages 55 to 59 inclusive.

When age differences in leadership are being studied, adequate allowance should be made for the fact that individuals do not always live to a ripe old age. Some die early; others in middle life. Therefore, since the representatives of the younger age groups are always likely to be more numerous than are the contemporary representatives of the older age groups, the younger age groups might conceivably exercise more frequent leadership merely because of their greater numerical strength. This difficulty has been overcome in the present study by computing the average amount of leadership that has been contributed by each age group.[1]

Fig. 1 (top) indicates that U. S. presidential nominations are most likely to be won by men whose ages are from 55 to 59 inclusive. This holds both for the successful and for the unsuccessful presidential candidates. It is worth noting, however, that the age range of the successful nominees is less than half as wide as is the age range of the unsuccessful nominees. For the successful nominees the age range is from 46 to 67, inclusive, a range of only 21 years. For the unsuccessful nominees, on the other hand, the age range is from 36 to 85, a range of 49 years.

Although some candidates have been nominated for the presidency while they were still in their thirties, and one vice-president succeeded to the presidency when he was not yet 43, no one has been elected to the presidency prior to age 46. And none has been elected subsequent to age 67. Theodore Roosevelt's first inauguration (at age 42) was due to the assassination of President McKinley. Theodore Roosevelt was elected president on November 8, 1904. He was born on October 27, 1858. He was, therefore, 46 years and 12 days old when he was elected president. U. S. Grant, the next most youthful president, was 46 years, 6 months and 7 days of age when first elected president. Although William Henry Harrison was not inaugurated until he was 68, his election occurred when he was 67 years old. The first Roosevelt and the first Harrison are thus the youngest and the oldest candidates, respectively, that have been elected presidents of the U. S. Since, for a

[1] When two or more age-curves are set forth in a single graph, the curves should be so drawn as to be comparable. In Fig. 1 (top) and the other graphs that accompany this article, the age-curves have all been rendered comparable by the following procedure. The peak of each statistical distribution was arbitrarily assigned a value of 100 per cent. and the other numerals within the same statistical distribution were assigned proportionate percentage values. For example, in Fig. 1 (top), for the successful candidacies, those shown by the broken line, the peak of the distribution occurred at ages 55 to 59, inclusive. At this latter age interval the average number of successful candidacies *per living individual* was .120. In Fig. 1 (top), at age interval 55 to 59, inclusive, the figure .120 is plotted, therefore, as 100 per cent. At age interval 60 to 64, on the other hand, the average number of successful candidacies per living individual was only .085. The decimal .085 is equivalent to only 71 per cent. of the maximum (71 per cent. of .120) and in Fig. 1 (top) the numeral .085 is plotted, therefore, as 71 per cent. The foregoing method of plotting the data should be borne in mind when studying the graphs, since this method takes account of the unequal numbers of individuals that were alive at the successive age intervals.

period of 150 years, the American voters have never elected a president of less than age 46, it seems apparent that the constitutional requirement that the president must be not less than age 35 has heretofore worked no particular hardship on potential candidates. Indeed, this constitutional requirement seems to have reflected rather than to have established custom and tradition.

Of the unsuccessful presidential candidates, William Jennings Bryan was nominated when he was only 36, and George B. McClellan was nominated at 38. Peter Cooper, on the other hand, was nominated when he was 85. It seems likely that Cooper had little hope of being elected and that he consented to be a candidate merely in order that he might bring before the public his views on the currency. The fact that the extremely young and the extremely old nominees have never once succeeded in their presidential candidacies may be due in part to the fact that very young and very old individuals are not likely to be nominated by the major political parties in which competition for the nomination is keenest. It is possible also that, even if they were to be nominated by the stronger political parties, the very young and the very old candidates would be handicapped in making their political campaigns.

In contrast to Fig. 1 (top), which reveals the ages at which American political leaders have attained presidential nominations, the solid line in Fig. 1 (middle) sets forth the chronological ages at which 218 deceased members of the cabinets of England served a total of 1,363 years. When two ministerial posts were held simultaneously, the years of such service were counted once only in the construction of Fig. 1 (middle). And when the same individual held various cabinet posts at different times, that individual's life-age was, of course, counted once only.

The broken line in Fig. 1 (middle) presents the ages at which 133 different individuals served as presidents of various republics of the world (other than the U. S. A.) for a total of 706 years.[2] Some of these 133 presidents and ex-presidents are still living. For others of them death dates could not be found. In the broken line of Fig. 1 (middle) allowance for the probable death rate of the presidents was made by assuming that their death rate would be the same as was the death rate for the deceased members of the British cabinets. This assumption, while not entirely valid, perhaps, is nevertheless more nearly valid than the assumption that the death rate for the contemporary presidents would be the same as the death rate for the population as a whole because the general population includes infants, children, invalids, and so forth.

Fig. 3 (top) presents: (1) The chronological ages at which the first 32 presidents of the U. S. A. served a total of 151 years, or fractions of years, as presidents,[3] and (2) the ages at which the last 29 hereditary rulers of France held their sovereignties. It reveals that, in proportion to the number alive at each successive age interval, hereditary rulers are most likely to serve as sovereigns from age 42½ until their deaths, whereas, as was stated previously, the presidents of the U. S. A. are most likely to serve as presidents during the relatively narrow age range of 55 to 59, inclusive.

The ages of the "chief ministers" of England from 920 to 1720, and of the British prime ministers since 1721 (2)

[2] The 133 presidents served from approximately 1890 to 1938, inclusive.

[3] In this article service for a fraction of a year has been counted the same as service for an entire year, since it is assumed that the fractional parts of years tend to distribute themselves over the entire age range in the same manner as do the whole years. For a reason that has been previously mentioned, the 32 presidents of the U. S. A. include only 31 different individuals.

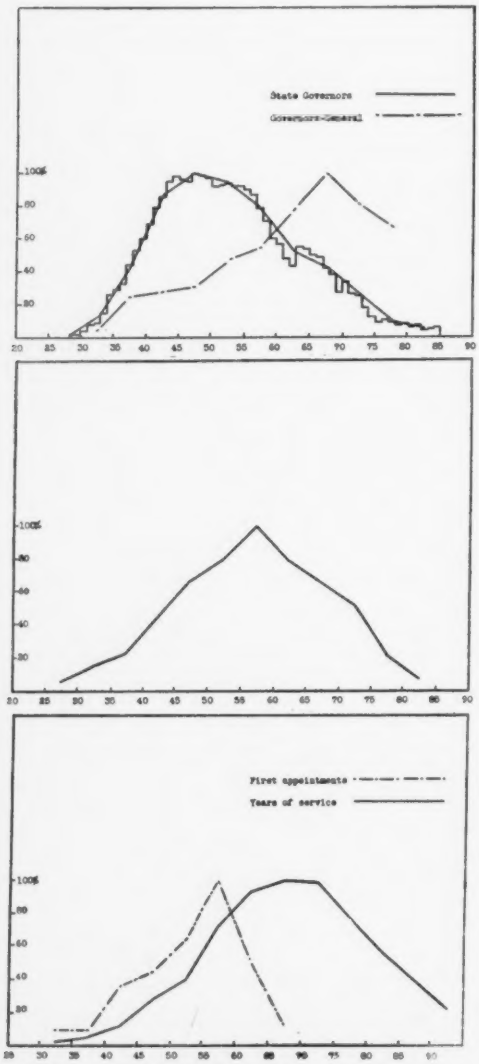


FIG. 2. GOVERNORS, AMBASSADORS, JUSTICES

Top: (A) AGES AT WHICH 932 DECEASED GOVERNORS OF STATES OF THE U.S. SERVED A TOTAL OF 3,885 YEARS, AND (B) AGES AT WHICH 32 GOVERNORS OF THE AMERICAN COLONIES HELD THEIR GOVERNORSHIPS. *Middle:* AMERICAN AMBASSADORS. AGES AT WHICH 176 DECEASED INDIVIDUALS REPRESENTED THE U.S. GOVERNMENT AS AMBASSADORS TO AUSTRIA-HUNGARY, ENGLAND, FRANCE, GERMANY, ITALY, JAPAN, RUSSIA AND SPAIN. *Bottom:* JUSTICES OF U.S. SUPREME COURT. (A) THE AGES OF 70 DECEASED JUSTICES AT THE TIME EACH WAS FIRST APPOINTED, AND (B) THE AGES AT WHICH THESE 70 MEN SERVED.

(3) were studied.[4] When these two sets of data were combined, Fig. 1 (bottom) was obtained. The reader will perhaps have noticed that, with the sole exception of the age-curve for hereditary rulers, all the age-curves presented thus far attain their peaks at ages 55 to 59, inclusive. It seems evident that, when political leadership depends upon somethings other than the accident of birth into a royal family, the most eminent leaders are most likely to reach the high points in their careers at ages 55 to 59, inclusive. However, for less outstanding political leaders, the above generalization may not hold true.

For example, Fig. 2 (top) presents: (1) The ages at which 932 governors of states of the U. S. A. served a total of 3,885 years, and (2) the ages at which 32 governors of the American colonies served a total of approximately (4, pp. 75 *ff.*) 286 years. It is evident from Fig. 2 (top) that the 32 governors of the American colonies were mostly elderly men. In many instances these colonial governors probably received their appointments as rewards for past services to the crown of England. In other instances they may have been given their

[4] In the following quotation Bigham explains the meaning of the term "chief ministers": "Ministers there always were, though it was only now and again that one of them became supreme. But if the prince was weak, or if he was often abroad, it was sometimes safer to commit the care of the realm to one individual rather than to several—a viceroy was better than a committee—and when the holder of such a charge was a man of mark, when he enjoyed in a special degree and for a considerable period the Sovereign's favor, then he overtopped his colleagues and became a Chief Minister. Insensibly the custom of having such an officer grew, and by the time that the nation was a conscious whole the idea of one particular statesman bearing the principal burden of government and wielding the principal power was already understood." (2) p. 1*f*. Eventually the "chief ministers" were replaced by the modern prime ministers. Sir R. Walpole is commonly regarded as the first of the prime ministers of England. Walpole became prime minister in 1721.

governorships for personal or for political reasons.

The solid line and the polygon of Fig. 2 (top) set forth data for 932 governors of the states of the U. S. since the American Revolution. Some of the 932 state governors were territorial governors appointed to office by the presidents of the U. S. Some were elected as lieutenant-governors and obtained their governorships as the immediate result of the death or the resignation of their predecessors in office. But most of the 932 governors were elected to office by their constituents. Since no difference in the shapes of the age-curves was found when data for the state governorships that were obtained in these three different ways were treated separately, the data for the 932 governors have been combined in constructing the solid line and the polygon of Fig. 2 (top). This solid line and the polygon reveal that, since the American Revolution, the state governors of the U. S. have served as governors most frequently when they were from ages 43 to 49, inclusive. The earlier ages of state governors than presidents of the U. S. is probably due in part to the fact that a governorship is often a stepping-stone to the presidency, many of the presidents having been state governors prior to their election as president.

Additional data regarding governors of the British dominions were obtained by study of the Governors-General of Canada since 1861, and for the Governors-General of British dominions other than Canada for the years 1890 to 1938, inclusive. The two age-curves which were constructed by use of these latter data each yielded a peak at ages 60 to 64, inclusive. One may conclude that American state governors are more often "on the make" politically than are the Governors-General of the British dominions.

American Ambassadors

Fig. 2 (middle) presents data for a sum total of 780 years of American diplomacy, namely, the chronological ages of 176 deceased ambassadors who have represented the U. S. government in Austria-Hungary, Great Britain, France, Germany, Italy, Japan, Russia and Spain, (4 pp. 67 *ff.*) from the time of the founding of the U. S. government until approximately the year 1900. It will be seen from Fig. 2 (middle) that the age interval of most frequent diplomatic service to major foreign powers is that from 55 to 59, inclusive. When diplomatic service to minor powers was studied similarly the resultant age-curve exhibited a much less definite peak. Very responsible diplomatic service is thus likely to be performed at a narrower age range than is diplomatic service of lesser importance. Some cynics may assert at this point that many of our foreign ambassadors have been incompetent amateurs who owed their diplomatic posts to the large campaign contributions which they made to the successful political parties rather than to their merit as ambassadors. As stated previously, the present article makes no attempt to evaluate the services of the leaders for whom data are presented herein.

Military and Naval Leaders

Fig. 3 (middle) reveals: (1) The ages at which 198 of the world's famous military leaders led their armies into 520 land battles, and (2) the ages at which 51 naval commanders led their fleets into 98 naval encounters. The age-curves of Fig. 3 (middle) are based upon the life records of such immortals as Alexander the Great, Frederick the Great, Julius Caesar, Napoleon, Admiral Nelson and scores of less renowned leaders. The names of the military and the naval leaders, the battles in which they served as commanders, and the dates on which

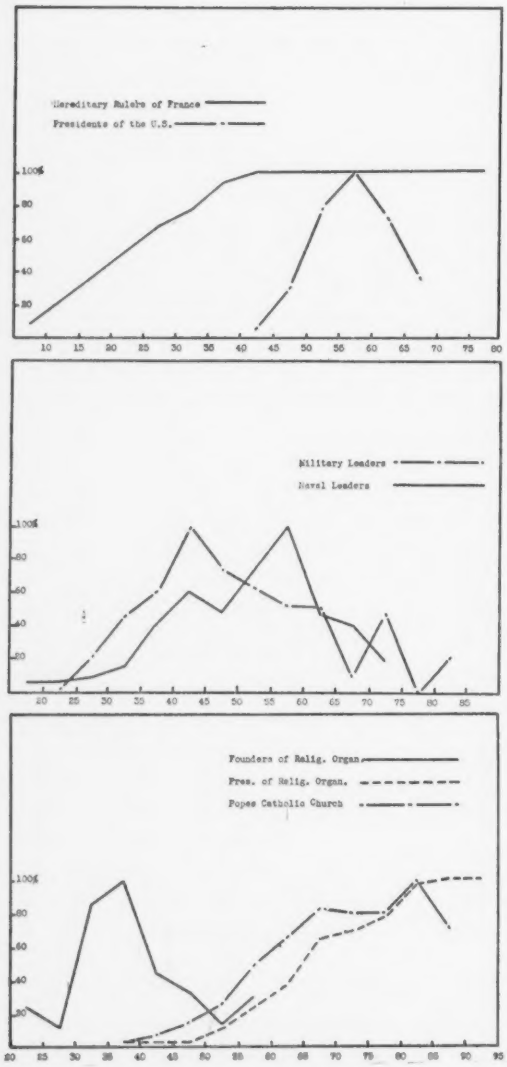


FIG. 3. STATE, WAR, RELIGIOUS LEADERS

Top: (A) AGES AT WHICH THE LAST 29 HEREDITARY RULERS OF FRANCE SERVED AS RULERS, AND (B) AGES AT WHICH PRESIDENTS OF THE U.S. SERVED AS PRESIDENTS FROM 1789 TO 1938, INCLUSIVE. *Middle:* WAR LEADERS. (A) AGES AT WHICH 198 DECEASED MILITARY LEADERS LED THEIR ARMIES INTO 520 LAND BATTLES, AND (B) AGES AT WHICH 51 DECEASED NAVAL COMMANDERS LED THEIR FLEETS INTO 98 NAVAL ENCOUNTERS. *Bottom:* RELIGIOUS LEADERS. (A) AGES AT WHICH 51 DECEASED INDIVIDUALS SERVED AS POPES OF THE ROMAN CATHOLIC CHURCH, (B) AGES AT WHICH 101 OTHER DECEASED INDIVIDUALS SERVED AS PRESIDENTS OF VARIOUS RELIGIOUS ORGANIZATIONS, AND (C) AGES AT WHICH 54 FOUNDERS OF RELIGIONS, AND OF RELIGIOUS SECTS AND SOCIETIES LAUNCHED THEIR MOVEMENTS.

they led their forces into battle, were obtained from Harbottle's "Dictionary of Battles" (5). In Fig. 3 (middle) data for military and naval commanders were included only when the leaders bore such purely military titles as general, field-marshal, admiral, colonel, and the like. Data for leaders who possessed royal titles such as king, prince, and so forth, were excluded because it was found that when data for royal leaders were used in the construction of age-curves, the curves tended to be broad and flat with no very definite peaks. It seems probable that, as compared with the non-royal leaders, the royal leaders were more often mere figure-heads who exercised little or no genuine leadership. It therefore seemed justifiable to omit data for the royal military and naval leaders.

Fig. 3 (middle) suggests that the non-royal military leaders were most frequently of ages 40 to 44, inclusive, whereas, the non-royal naval commanders were most frequently of ages 55 to 59, inclusive. Is this difference in the peaks of the age-curves due to the different demands that are made upon the two kinds of commanders? Or is it perhaps due to custom, tradition and other factors of doubtful relevance? To the present writer it seems likely that subordinate army officers are more frequently given opportunity to command separate military units, and thus to reveal their real ability as leaders, than are subordinate naval officials. If this hypothesis is valid, it would explain why seniority is more easily brushed aside in the army than in the navy. Another possible explanation is the fact that the number of different individuals who acquire technical naval training is probably not as great as is the number

who receive technical military training. Finally, it is to be remembered that most of the naval leaders are of relatively recent date; many of the generals lived in earlier times, and physical vigor was probably more essential to military leadership in earlier times.

Judicial Leaders: Members of the U. S. Supreme Court

Fig. 2 (bottom) sets forth: (1) The ages of 70 deceased justices of the U. S. Supreme Court at the time each of these individuals received his first appointment thereto, and (2) the ages at which these 70 justices served as members of the Supreme Court. Collectively, the 70 justices served a total of approximately 1,444 years (4, pp. 73 *ff.*). Fig. 2 (bottom) reveals that some justices were appointed to the Supreme Court while they were still in their thirties. These latter appointments were made during the early days of the republic when young men comprised a much larger proportion of the total population than they do to-day. Fig. 2 (bottom) reveals further that, although some individuals received their first appointments to the Supreme Court when they were in their sixties, the largest number were first appointed when they were from 55 to 59, inclusive.

The solid line of Fig. 2 (bottom) shows that, although a few of them have served prior to age 35 and certain others have served when they were beyond 90, justices of the U. S. Supreme Court have served most frequently at ages 65 to 69, inclusive. Eighty-eight per cent. of the U. S. Supreme Court service has been rendered by men who were beyond 50 years of age, and 41 per cent. of such service has been rendered by men who were above 65. This finding is perhaps due in part to the well-known fact that the age of retirement for justices of the Supreme Court is contingent upon the personal desires of the incumbents. When retirement from a position of power and prestige is left to the pleasure of the incumbent, retirement is likely to be much delayed, and sometimes it does not occur at all.

Data were obtained similarly for 55 deceased federal district and circuit court judges who served collectively for a total of 1,205 years. The average length of service for these judges was almost 22 years, and they served most frequently at ages 60 to 64, inclusive. The fact that the federal district and circuit judges have served at somewhat younger chronological age levels than have the justices of the Supreme Court may be due in part to the fact that the federal district and circuit courts serve as "feeders" to the U. S. Supreme Court.

Members of the President's Cabinet

When age-curves were drawn portraying: (1) The ages of *attaining* membership in the cabinet of the president of the U. S. A., and (2) the ages of *serving* in the president's cabinet, the latter two curves were found to be of almost identical shape, the maximum points of both of these age-curves occurring at ages 50 to 54. (See Fig. 4, top.) The reason for the similarity in the shapes of these latter two age-curves is perhaps partly the fact that members of the president's cabinet usually resign their positions whenever a new president is elected. In the U. S. it is true also that cabinet members sometimes resign their posts in order to engage in private endeavor, or to work, as lobbyists and the like, for various business groups. The fact that, in the U. S., membership in the president's cabinet is so often regarded as a stepping-stone to "something better" may account in part both for the fact that the two age-curves in Fig. 4 (top) are so nearly identical in shape and also for the fact that the members of the president's cabinet tend to be somewhat younger than do members of British cabinets.

Professional Leadership: Presidents of National Professional Organizations

A curve was constructed which set forth the chronological ages at which 915 Americans were honored by being elected as presidents of over 50 national scientific and learned societies (4, pp. 133–138). The peak of this curve occurred at ages 50 to 54, inclusive. It was found, however, that professional recognition and leadership are won much more quickly in some lines of endeavor than in others. Past presidents of both the American Medical Association and the American Bar Association were found to have held their presidencies most often at ages 60 to 64, inclusive. (See Fig. 4, middle.) But for both the American Chemical Society and the American Psychological Association past presidents have served most frequently from ages 45 to 49.

Religious Leadership

Fig. 3 (bottom) sets forth: (1) The ages at which 51 deceased men served a total of 495 years as popes of the Roman Catholic Church, (2) the ages at which 101 other individuals served a total of 770 years as presidents of 13 different religious organizations (4, pp. 133 *ff.*), and (3) the ages at which 54 deceased founders of religions, and of religious sects and societies, first launched their movements (4, p. 152; 7, 6). It should be understood, of course, that many of these founders continued to preach and to carry on their work as long as they lived. And, in many instances, the influence of these founders continued to increase even after their deaths.

Fig. 3 (bottom) suggests that, whereas, new religious movements are most likely to be launched by individuals who are still in their thirties, after they have once been established, religious organizations are likely to receive most of their nominal leadership from rather elderly men. Thus, more than 97 per cent. of the papal years of service were rendered by men who were past 50, and more than 65 per cent. of the papal years of service were rendered by men who were of ages 65 or above. Of the presidents of the non-Catholic religious organizations, 93 per cent. of their administrative years were contributed by persons of more than age 50, and 56 per cent. of this service was rendered by persons over 65.

Similar data were assembled for 148 deceased Protestant bishops who served as bishops for a total of 3,007 years, the average length of service as a bishop being 20.32 years. The peak of the age-curve that was constructed by use of these data occurred at ages 70 to 74. The ages of members of the College of Cardinals of the Roman Catholic Church for the 11-year period, from 1928 to 1938, inclusive, were likewise studied. The apogee of the resultant age-curve occurred at ages 65 to 69. Collectively, the foregoing figures seem to validate an assertion that was made some years since by G. Stanley Hall, namely:

> Thus it came that, while men in their prime conceived the great religions, the old made them prevail. Thus, too, instituted and dogmatic religion owes its existence chiefly to men past the meridian of life. The old did not invent belief in supernatural powers or persons but needed and used it to sustain their position when physical inferiority would have otherwise compelled them to step aside and so they made themselves mediators between gods and men. They directed and presided over rites and ceremonies and took possession of the keys of the next world, enforced orthodoxies for the sake of order, and established and equipped the young to aid them in this work. They were behind the scenes and held the secrets, realizing the utility to society and also to themselves of much for which they had lost the primitive ardor of belief. Thus the revivalist and the reformer have always found the old arraigned against them. (8, p. 420.)

Educational Leaders

Fig. 4 (bottom) the dash line presents the chronological ages at which 364 American college and university presi-

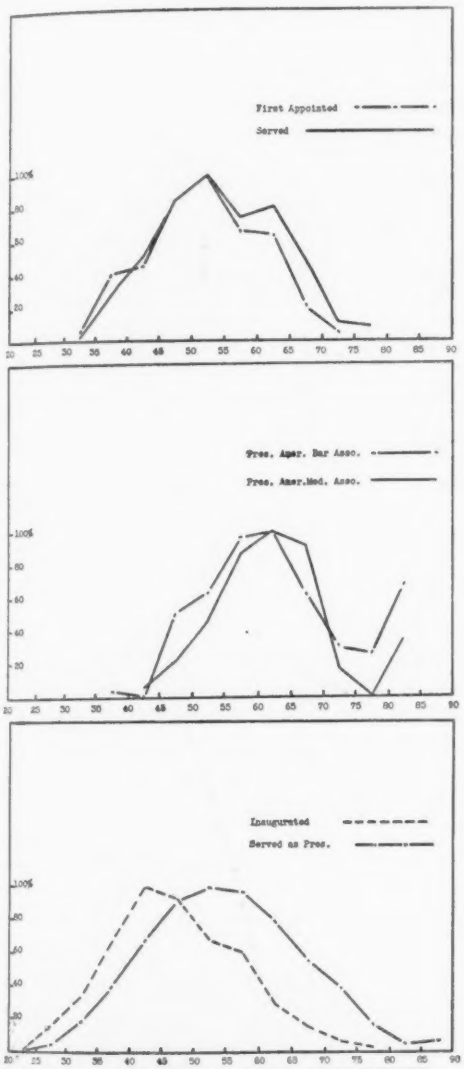


FIG. 4. POLITICS, LAW, MEDICINE, EDUCATION

Top: (A) AGES AT WHICH 248 DECEASED INDIVIDUALS ATTAINED MEMBERSHIP IN THE CABINET OF THE PRESIDENT OF THE U.S., AND (B) AGES AT WHICH THESE 248 INDIVIDUALS SERVED A TOTAL OF 1,017 YEARS. *Middle:* PROFESSIONAL LEADERS. (A) AGES OF 57 PAST PRESIDENTS OF THE AMERICAN BAR ASSOCIATION, AND (B) AGES OF 91 PAST PRESIDENTS OF THE AMERICAN MEDICAL ASSOCIATION. *Bottom:* EDUCATIONAL LEADERS. (A) AGES AT WHICH 364 AMERICAN COLLEGE AND UNIVERSITY PRESIDENTS WERE INAUGURATED AS PRESIDENTS, AND (B) AGES AT WHICH THESE 364 INDIVIDUALS SERVED AS COLLEGE AND UNIVERSITY PRESIDENTS.

dents were inaugurated as presidents (4, pp. 117 *ff.*). In this figure data are presented for 450 inaugurations but for only 364 different individuals. This apparent discrepancy is due to the fact that when a given president moved from one college to be the president of another, that individual's inauguration was counted as often as he became a "new" college president.

The five-year interval during which "new" college presidents are most frequently inaugurated seems to be that from ages 40 to 44, inclusive. This is the age interval during which American college and university presidents have been most often inaugurated as presidents from the time of the establishment of the 56 leading educational institutions for which data were available until approximately the year 1900. An attempt was made to partition the data for the presidencies of large, as compared with those for small institutions, and for privately endowed as compared with state universities. No significant age differences were found when the data were thus partitioned and the present writer doubts that they exist.

A college president's inauguration marks only the beginning of his administration. During what years of their lives are college and university presidents most likely to exercise their presidential functions? The broken line of Fig. 4 (bottom) reveals that, in proportion to the number of them that are alive at each successive age interval, American college and university presidents serve as presidents most frequently from ages 50 to 54. The age interval of most frequent service is thus ten years later than is the age interval of most frequent inauguration.

COMMERCIAL AND INDUSTRIAL LEADERS

In Fig. 5 (top) the dash line sets forth the ages of approximately 1,400 individuals whose names were found in the

1938 edition of "Who's Who in Commerce and Industry" (9). The broken line of this figure sets forth a second sampling of approximately the same size as the first sampling. The method that was employed by the editors for selecting the business and the financial leaders whose names are included in "Who's Who in Commerce and Industry" is described in the following explanatory paragraphs which are taken from the preface of the book:

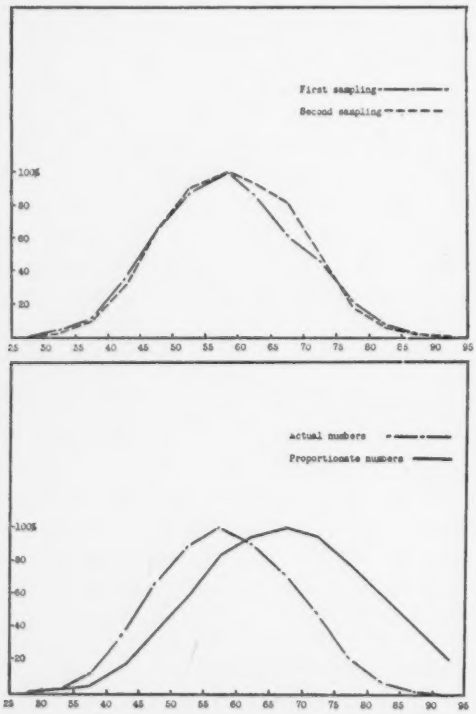


FIG. 5. LEADING MEN IN BUSINESS

Top: AGES OF MEN WHOSE NAMES WERE INCLUDED IN THE 1938 EDITION OF WHO'S WHO IN COMMERCE AND INDUSTRY. (A) FIRST SAMPLE OF APPROXIMATELY 1,400 NAMES. (B) SECOND SAMPLE OF APPROXIMATELY 1,400 NAMES. *Bottom:* AGES OF 2,800 MEN WHOSE NAMES WERE INCLUDED IN THE 1938 EDITION OF WHO'S WHO IN COMMERCE AND INDUSTRY. (A) NO ALLOWANCE IS HERE MADE FOR POPULATION DIFFERENCES AT SUCCESSIVE AGE LEVELS. (B) ALLOWANCE IS HERE MADE FOR POPULATION DIFFERENCES AT SUCCESSIVE AGE LEVELS.

> The volume lists the chairmen of boards, presidents and other important officers of industrial, manufacturing and transportation corporations; executives of utilities, communications and mining companies; heads of insurance companies, financial and investment institutions and banks; merchants of leading department stores and mercantile establishments, and elected officers of national and international trade associations.
>
> Not all persons prominent in commerce and industry are included in this volume. Only the most important executives are listed. Generally, the book contains the heads of corporations whose net worth is over $1,000,000.00. Aside from other special considerations, that is the basic principle underlying the admission of business leaders. Needless to say, with such stringent requirements for admission, only those deservant of inclusion can find their way into this book.
>
> . . . There is no charge for the inclusion of biographies in "Who's Who in Commerce and Industry." *Not a single name in the book has been paid for and none can be paid for.* (9, pp. iii–iv.)

Since the two age-curves of Fig. 5 (top) are almost identical in shape, the data for both curves were combined in constructing the broken line of Fig. 5 (bottom). In examining the broken line of Fig. 5 (bottom) the reader should bear in mind that this curve presents merely the absolute numbers of commercial and industrial leaders per chronological age interval, no allowance being made in this curve for the fact that the representatives of the younger age groups are more numerous than are the representatives of the older age groups. The solid line of Fig. 5 (bottom), on the other hand, takes into account the population differences at the various age levels.

The two curves of Fig. 5 (bottom) reveal that although, as regards absolute numbers, the eminent leaders in commerce and industry are most frequently of ages 55 to 59, inclusive, when proper allowance is made for the fact that fewer persons are alive at the older age levels, the resultant age-curve attains its peak at ages 65 to 69, inclusive. In other words, in proportion to its size, age

group 65 to 69 contributes the most commercial and industrial leadership. In studying the curves of Fig. 5 (bottom) the reader should also remember that none of the leaders whose names were listed in "Who's Who in Commerce and Industry" had retired at the time the foregoing volume was published. All were nominally active officials in large business and industrial concerns.

Concluding Remarks

Because competition and struggle play such a large part in all life, some philosophers have advanced the theory that power is the most universal and the most fundamental of human motives. Some have even gone so far as to insist that every man is basically a *Machtmensch*, man's most coveted goal being the enhancement of his own personal power. The present study assumes only that within each of the age groups there are numerous individuals who would have attained the kinds of leadership that have been cited herein if they had been able to do so. If this latter assumption is a valid one, it may be inferred that the accompanying age-curves reveal the relative ability of the members of the several age groups to acquire and to retain the types of leadership that have been mentioned herein.

One need not infer that any of these curves reveals the chronological ages at which adult "general intelligence" is at its maximum. There are, of course, many different kinds of leadership and the peak of the age curve varies somewhat with the kind of leadership that is under consideration. For example, the military leaders have been most frequently of ages 40 to 44, whereas, the top-flight political leaders have been most frequently of ages 55 to 59, inclusive. Moreover, it seems obvious that a given type of leadership, for example, political leadership, is often due not to any one variable, but to an indeterminate number of such factors as self-confidence, forcefulness, persistence, the art of persuasion, the ability to grasp and to express the will of the masses, the ability to compromise, the times during which the leader lives, and so forth. Some writers would maintain that the leader is not a biologically recognizable variety of human being at all, and that much leadership is, in part at least, a sociological phenomenon. For example, is Adolf Hitler's political leadership an inevitable personal characteristic which Hitler could not have escaped, or is Hitler's leadership not due in part to the times, and to the situation that resulted from the enforcement of the provisions of the Treaty of Versailles? Probably no competent thinker would insist that there is any *one* variable that enabled Hitler to attain his leadership, or that Hitler would have attained equal eminence as a leader if he had been born a hundred years prior to the First World War.

Volumes might easily be written in an attempt to set forth the full meaning and the various implications that may be derived from the accompanying age-curves. In the brief space at his disposal, the writer will touch briefly upon only one or two of the very large number of aspects that might well have been considered.

As has been pointed out by G. Stanley Hall (8) and others, during the evolution of *homo sapiens*, those aging individuals who have felt their physical powers beginning to wane, at least the more sagacious of them, have invented or adopted numerous devices by means of which they have safeguarded their persons, their goods and their prestige. When the sub-human organism's physical powers begin to wane, the sub-human creature is likely to lose its rôle of leadership rather quickly. Man (the political animal), however, has evolved

1938 edition of "Who's Who in Commerce and Industry" (9). The broken line of this figure sets forth a second sampling of approximately the same size as the first sampling. The method that was employed by the editors for selecting the business and the financial leaders whose names are included in "Who's Who in Commerce and Industry" is described in the following explanatory paragraphs which are taken from the preface of the book:

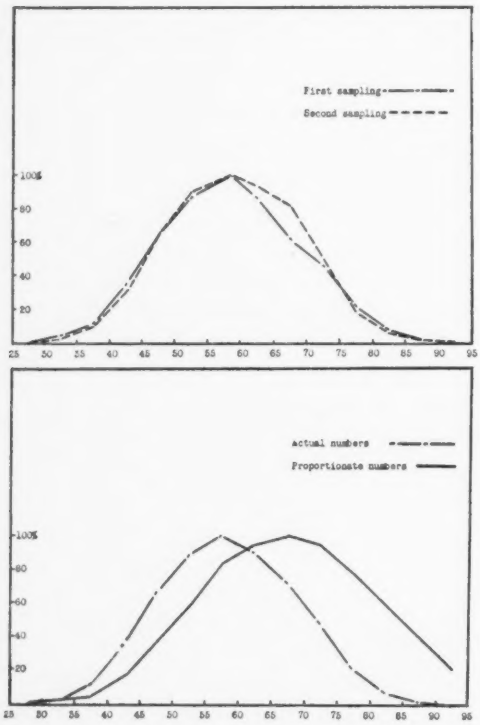


FIG. 5. LEADING MEN IN BUSINESS

Top: AGES OF MEN WHOSE NAMES WERE INCLUDED IN THE 1938 EDITION OF WHO'S WHO IN COMMERCE AND INDUSTRY. (A) FIRST SAMPLE OF APPROXIMATELY 1,400 NAMES. (B) SECOND SAMPLE OF APPROXIMATELY 1,400 NAMES. *Bottom:* AGES OF 2,800 MEN WHOSE NAMES WERE INCLUDED IN THE 1938 EDITION OF WHO'S WHO IN COMMERCE AND INDUSTRY. (A) NO ALLOWANCE IS HERE MADE FOR POPULATION DIFFERENCES AT SUCCESSIVE AGE LEVELS. (B) ALLOWANCE IS HERE MADE FOR POPULATION DIFFERENCES AT SUCCESSIVE AGE LEVELS.

> The volume lists the chairmen of boards, presidents and other important officers of industrial, manufacturing and transportation corporations; executives of utilities, communications and mining companies; heads of insurance companies, financial and investment institutions and banks; merchants of leading department stores and mercantile establishments, and elected officers of national and international trade associations.
>
> Not all persons prominent in commerce and industry are included in this volume. Only the most important executives are listed. Generally, the book contains the heads of corporations whose net worth is over $1,000,000.00. Aside from other special considerations, that is the basic principle underlying the admission of business leaders. Needless to say, with such stringent requirements for admission, only those deservant of inclusion can find their way into this book.
>
> . . . There is no charge for the inclusion of biographies in "Who's Who in Commerce and Industry." *Not a single name in the book has been paid for and none can be paid for.* (9, pp. iii–iv.)

Since the two age-curves of Fig. 5 (top) are almost identical in shape, the data for both curves were combined in constructing the broken line of Fig. 5 (bottom). In examining the broken line of Fig. 5 (bottom) the reader should bear in mind that this curve presents merely the absolute numbers of commercial and industrial leaders per chronological age interval, no allowance being made in this curve for the fact that the representatives of the younger age groups are more numerous than are the representatives of the older age groups. The solid line of Fig. 5 (bottom), on the other hand, takes into account the population differences at the various age levels.

The two curves of Fig. 5 (bottom) reveal that although, as regards absolute numbers, the eminent leaders in commerce and industry are most frequently of ages 55 to 59, inclusive, when proper allowance is made for the fact that fewer persons are alive at the older age levels, the resultant age-curve attains its peak at ages 65 to 69, inclusive. In other words, in proportion to its size, age

group 65 to 69 contributes the most commercial and industrial leadership. In studying the curves of Fig. 5 (bottom) the reader should also remember that none of the leaders whose names were listed in "Who's Who in Commerce and Industry" had retired at the time the foregoing volume was published. All were nominally active officials in large business and industrial concerns.

Concluding Remarks

Because competition and struggle play such a large part in all life, some philosophers have advanced the theory that power is the most universal and the most fundamental of human motives. Some have even gone so far as to insist that every man is basically a *Machtmensch,* man's most coveted goal being the enhancement of his own personal power. The present study assumes only that within each of the age groups there are numerous individuals who would have attained the kinds of leadership that have been cited herein if they had been able to do so. If this latter assumption is a valid one, it may be inferred that the accompanying age-curves reveal the relative ability of the members of the several age groups to acquire and to retain the types of leadership that have been mentioned herein.

One need not infer that any of these curves reveals the chronological ages at which adult "general intelligence" is at its maximum. There are, of course, many different kinds of leadership and the peak of the age curve varies somewhat with the kind of leadership that is under consideration. For example, the military leaders have been most frequently of ages 40 to 44, whereas, the top-flight political leaders have been most frequently of ages 55 to 59, inclusive. Moreover, it seems obvious that a given type of leadership, for example, political leadership, is often due not to any one variable, but to an indeterminate number of such factors as self-confidence, forcefulness, persistence, the art of persuasion, the ability to grasp and to express the will of the masses, the ability to compromise, the times during which the leader lives, and so forth. Some writers would maintain that the leader is not a biologically recognizable variety of human being at all, and that much leadership is, in part at least, a sociological phenomenon. For example, is Adolf Hitler's political leadership an inevitable personal characteristic which Hitler could not have escaped, or is Hitler's leadership not due in part to the times, and to the situation that resulted from the enforcement of the provisions of the Treaty of Versailles? Probably no competent thinker would insist that there is any *one* variable that enabled Hitler to attain his leadership, or that Hitler would have attained equal eminence as a leader if he had been born a hundred years prior to the First World War.

Volumes might easily be written in an attempt to set forth the full meaning and the various implications that may be derived from the accompanying age-curves. In the brief space at his disposal, the writer will touch briefly upon only one or two of the very large number of aspects that might well have been considered.

As has been pointed out by G. Stanley Hall (8) and others, during the evolution of *homo sapiens,* those aging individuals who have felt their physical powers beginning to wane, at least the more sagacious of them, have invented or adopted numerous devices by means of which they have safeguarded their persons, their goods and their prestige. When the sub-human organism's physical powers begin to wane, the sub-human creature is likely to lose its rôle of leadership rather quickly. Man (the political animal), however, has evolved

means of social control which enable him to exert his greatest political influence in his late fifties. In a former study (1–f) data were published which suggest that man attains the peak of his physical strength and skill at about age 27 or 28. The present study suggests that man does not attain his full political stature until approximately 30 years after he has passed the peak of his physical prowess. Collectively, these studies thus reveal a situation that is quite different from that which is to be found in any of the lower animal groups.

It is obvious that in human society the various age groups have innumerable mutual interests. It is equally apparent that in some respects the old and the young are in a state of constant competition. Although our data reveal that, in the struggle for leadership, the older age groups have been eminently successful, they show also that the chronological age at which one is most likely to do his most important work varies with the nature of the task. It seems clear that for many activities there exists a relatively brief age interval during which groups of individuals will be most likely to attain their greatest success. For example, it has been shown in former articles (1) that several kinds of creative thinking are most likely to culminate when the creative thinker is still in his thirties. But the present study suggests that the top of the political ladder is most likely to be reached by men who are in their late fifties.

This study has dealt only with the age factor. Clearly the statistical distribution of these eminent leaders at various periods of their lives with respect to such factors as height, weight, intelligence-test scores, extroversion-introversion scores, educational attainment, and the like, would be equally as, if not more, interesting than is the statistical distribution of their ages. Fairly complete individual case-studies would be even more interesting. Unfortunately, chronological age is about the only kind of adequate information that the present writer has been able to obtain regarding these leaders.

AVERAGE AMOUNT OF VARIOUS KINDS OF LEADERSHIP PER FIVE-YEAR INTERVAL. THE PEAK OF EACH STATISTICAL DISTRIBUTION IS IN ITALICS

Type of leadership	Age-interval										
	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
Successful U. S. pres. candidacies	...	...	...	.037	.061	*.120*	.085	.042	...	...	...
Unsuccessful U. S. pres. candidacies	...	.008	.016	.040	.069	*.082*	.063	.053	.043	.015	.032
Members of the cabinets of England	.034	.051	.109	.207	.242	*.289*	.209	.188	.150	.116	.070
Pres. of republics other than the U. S. A.	.005	.024	.056	.096	.133	*.168*	.140	.137	.091	.063	.053
Hereditary rulers of France	.783	.939	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	...
Pres. of the U. S. Ages of serving	...	...	.019	.110	.278	*.366*	.261	.129	...	...	...
The "chief ministers" and the prime ministers of England	.073	.151	.197	.325	.325	*.389*	.318	.268	.324	.240	.147
State governors of the U. S.	.023	.079	.155	.177	.169	.141	.094	.076	.045	.018	.012
Gov. of the Amer. colonies	.025	.113	.127	.140	.218	.250	.357	*.456*	.371	.306	...
U. S. ambassadors. Ages of serving	.028	.042	.084	.126	.149	*.187*	.146	.119	.096	.040	.011
Non-hereditary military commanders	.056	.074	*.120*	.090	.077	.062	.064	.012	.058	...	.027
Non-hereditary naval commanders	.012	.033	.049	.039	.060	*.080*	.038	.032	.016	...	...
Justices U. S. Supreme Court	.006	.006	.023	.029	.042	*.064*	.033	.009	...	...	...
Justices U. S. Supreme Court	.014	.043	.097	.235	.335	.606	.776	*.838*	.832	.730	.480
Members of Pres. cab.	.002	.020	.023	.044	*.051*	.034	.033	.011	.002	...	...
Members of Pres. cab. Ages of serving	.004	.055	.098	.162	*.191*	.142	.156	.091	.020	.017	...
Pres. Amer. Bar Asso. Ages of serving	...	...	.004	.014	.029	.053	*.061*	.056	.011	...	.022
Pres. Amer. Med. Asso. Ages of serving	...	.003	...	.025	.031	.048	*.051*	.036	.019	.023	.036
Founders of religions and sects	.052	*.060*	.027	.020	.009	.018	...	...	...	...	...
Popes. Ages of serving	...	.020	.020	.020	.096	.227	.363	.643	.686	.771	.980
Pres. of other religious organizations	...	.008	.030	.059	.112	.208	.276	.355	.343	.341	*.426*
Pres. Amer. Col. and Univ.	.018	.037	*.054*	.051	.037	.033	.016	.008	.003	.002	...
Pres. Amer. Col. and Univ.	.077	.164	.272	.378	*.409*	.397	.324	.223	.160	.071	.023
Commercial and industrial leaders*	23	59	175	337	455	518	463	367	245	106	36

Additional age ranges: 85–89: unsuccessful presidential candidacies, .067; members of English cabinets, .029; presidents of republics, .059; ministers of England, .083; justices U. S. Supreme Court, .333 (ages 90–94, .185); popes, 1.00 (ages 90–94, 1.00); presidents of religious org., .300; presidents of Amer. Col. & Univ., .027.

* For the commercial and industrial leaders absolute numbers are given, no allowance being made for population differences at the various age levels.

SUMMARY OF FINDINGS WITH REFERENCE TO CHRONOLOGICAL AGE AND TYPE OF LEADERSHIP

Type of leadership	No. of cases	No. of men	Ave. per indiv.	Median C.A.	Mean C.A.	S.D.	Peak years
Successful U. S. pres. candidacies	38	27	1.41	56.6	56.98	5.60	55–59
Unsuccessful U. S. pres. candidacies	108	73	1.16	57.0	57.36	9.30	55–59
Members of the cabinets of England	1,363	218	6.25	55.23	55.35	10.80	55–59
Pres. of republics other than the U. S. A.	706	133	5.31	56.87	57.37	10.55	55–59
Hereditary rulers of France. Ages of serving	762	29	26.3	36.23	36.23	13.85	42+
Pres. of the U. S. Ages of serving	151	31	4.87	56.2	56.37	5.80	55–59
"Chief ministers" and prime ministers of England	599	63	9.50	53.45	53.54	12.20	55–59
State governors of the U. S. Ages of serving	3,885	932	4.17	49.63	50.47	9.55	43–49
Gov. of the Amer. colonies. Ages of serving	286	32	8.94	61.50	59.20	10.10	65–69
U. S. ambassadors. Ages of serving	780	176	4.43	57.67	54.69	10.80	55–59
Non-hereditary military commanders	520	198	3.63	44.91	46.51	11.38	40–44
Non-hereditary naval commanders	118	83	1.42	50.25	48.90	11.43	55–59
Justices U. S. Supreme Court. Ages when app'ted.	70	70	....	49.46	53.01	7.85	55–59
Justices U. S. Supreme Court. Ages of serving	1,144	70	16.34	62.62	62.45	10.10	65–75
Members of Pres. cab. Ages when appointed	248	248	....	50.94	51.21	8.30	50–54
Members of Pres. cab. Ages of serving	1,017	248	4.10	52.68	52.77	8.60	50–54
Pres. Amer. Bar. Asso. Ages of serving	57	57	1.00	60.38	65.22	7.30	60–64
Pres. Amer. Med. Asso. Ages of serving	91	91	1.00	59.27	64.42	8.65	60–64
Founders of religions and sects	54	54	1.00	37.75	39.26	8.35	35–39
Popes. Ages of serving	495	51	9.70	67.33	68.41	9.15	82–92
Pres. of other religious organizations	770	101	7.62	64.81	66.01	10.00	80–84
Pres. Amer. Col. and Univ. Ages when inaug.	450	364	1.24	45.54	46.34	9.60	40–44
Pres. Amer. Col. and Univ. Ages of serving	3,853	364	10.58	52.18	52.50	10.50	50–54
Commercial and industrial leaders	2,800	2,800	....	57.07	58.60	10.4	65–69

1. (a) Lehman, H. C.: "The Creative Years in Science and Literature," THE SCIENTIFIC MONTHLY, 43: 151–162, 1936.
   (b) Heidler, J. B., and Lehman, H. C.: "Chronological Age and Productivity: Various Types of Literature," *The English Journal* (College Edition) 155: 294–304, 1937.
   (c) Lehman, H. C., and Ingerham, D. W.: "Man's Creative Years in Music," THE SCIENTIFIC MONTHLY, 48: 431–443, 1939.
   (d) Lehman, H. C.: "The Creative Years: 'Best Books,'" THE SCIENTIFIC MONTHLY, 45: 65–75, 1937.
   (e) Lehman, H. C.: "The Creative Years: Medicine, Surgery, and Certain Related Fields," THE SCIENTIFIC MONTHLY, 48: 450–462, 1941.
   (f) Lehman, H. C.: "The Most Proficient Years at Sports and Games," *The Research Quarterly* of the American Association for Health and Physical Education, 11: 3–19, 1938.
2. Bigham, C.: "The Chief Ministers of England 920–1720." New York: E. P. Dutton and Company, 1923. Pp. x + 422.
3. Encyclopedia Britannica. Fourteenth Edition. Vol. 15. Pp. 551 *ff*.
4. "The National Cyclopedia of American Biography." Index and Conspectus. New York: James T. White and Company, 1906.
5. Harbottle, E. B.: "Dictionary of Battles from the Earliest Date to the Present Time." New York: E. P. Dutton and Company, 1905. Pp. 298.
6. Hastings, J.: "Encyclopedia of Religion and Ethics." New York: Charles Scribner's Sons. 1923. In 13 volumes.
7. Hume, R. E.: "The World's Living Religions." New York: Charles Scribner's Sons. 1935. Pp. viii + 312.
8. Hall, G. S.: "Senescence: The Last Half of Life." New York: D. Appleton and Company, 1923. Pp. xxvii + 525.
9. "Who's Who in Commerce and Industry. The International Business 'Who's Who.'" New York: Institute for Research in Biography, Inc., 2nd edition, 1938. Pp. viii + 1010.

SCIENCE AND JOHN DONNE

By O. P. TITUS

EVENING COLLEGE, UNIVERSITY OF CINCINNATI

Publication of Ernest Hemingway's "For Whom the Bell Tolls" has brought about another revival of interest in the writings of John Donne. Whether this interest springs from superficial curiosity, a response to the beauty of the quotation from which Hemingway takes his title, or from a deeper felt affinity in thought and feeling with Donne's idea of the interrelation and interdependence of men, which is daily and irresistibly forced upon us by the present horrors of world war, is impossible to say. It would be interesting to know the reactions of the new readers of John Donne, to know how a closer acquaintance with the sixteenth century genius affects them, whether or not this new impetus to interest in Donne will outlast or outgrow, in a popular sense, that other revival which took its rise in the 1912 edition of Donne's poems by Professor Grierson, and which reached such literary proportions that by 1926, as T. S. Eliot says, "the subject was already popular, almost topical."

That many who approach Donne in curiosity will remain to read with amazement and pleasure is obvious. There is a curious kinship in the bewilderment felt by thousands, oppressed by the cataclysmic events of to-day, with the personal bewilderment and soul-torment felt by Donne, living in an age of scientific revolution.

Born in 1573, Donne came into a world shaped by medieval scholasticism, a world apparently forever secure in its physical and spiritual boundaries. It proved, however, a world to be wholly reshaped by the scientific discoveries of Copernicus, Kepler, Tycho Brahe and Galileo. That Donne's peculiar difficulties and torments were due wholly to this fact is not true. "Science is only one of the things which color the glass through which the writer looks at life." Donne's troubles arose, as well, from the circumstances of his religious environment, his temperament and his secret marriage, with its disastrous effects on his prospects of court preferment. But the effect of the doubt cast by science on man's material universe undoubtedly played its part in Donne's distrust of reason and ultimate triumph in faith, and was mirrored in his poetry and prose to such an extent that "the break-up of a whole system of thought is reflected in his pages," so that in them may be seen "the effort of the late Renaissance mind to make adjustment to its world of changing values without sacrificing its regard for the equal claims of emotion and reason."

Donne was the son of a prosperous trader. His mother was the daughter of John Heywood, epigrammatist and writer of interludes, and the granddaughter of Sir Thomas More. He was brought up under strict Catholic guidance and in an atmosphere of intrigue and persecution. Although Donne, after his years of doubt and study, rejected the Catholic faith and later attacked the Jesuits in "Ignatius, his Conclave," he received from his early training an impress which lasted throughout his life.

In an age in which men had an immoderate thirst for learning, Donne's learning was immense. He had a feverish craving for experience and excitement and says of himself that he had "an Hydroptique, immoderate desire of humane learning and languages." It was these characteristics which led

Donne to study languages and law, to master "the grounds and uses of physic," to compare with passionate attention the doctrines of the Catholic church and the Church of England, and to read with open mind the scientific writings of Copernicus, Kepler, Tycho Brahe, Galileo and others, and which are reflected in his poems and prose. In the "Satires" he says that he was to be found at midnight "fighting in the streets with untrussed gallants" and in the poems, "The Storm" and "The Calm," he writes vividly of his experiences when on a naval expedition in the service of the Lord of Essex which was undertaken, he says in "The Calm," from

> . . . hope of gaine,
> Or to disuse mee from the queasie paine
> Of being belov'd, and loving, or the thirst
> Of honour. . . .

The profligacy of Donne's youth has been questioned and the suggestion made that his cynical attitude toward women may have been, in part, a pose and a species of bravado. The evidence in the "Satires" and "Songs and Sonnets" scarcely seems to bear this out. In his later life Donne certainly felt and expressed great regret for the adventures of his youth, which must have been, even in those times, somewhat too openly chronicled and detailed for the peace of mind of a man who had become a great dignitary in the Church of England, one whose religious faith had come to equal in intensity his youthful qualities of skepticism and cynicism, and who, despite his attitude toward women, had sacrificed all material prospects for love and had found in his love for his wife, Anne More, a steadfast anchorage in sickness, poverty and disappointment.

The revolution in the state of mind of the Donne who wrote "The Canonization" in comparison with that of the Donne who, with St. Augustine, could cry in yearning, "Too late have I sought Thee oh Beauty old yet ever new," is equally as great as that brought about in the conception of the universe by the accumulation of facts about nature and the development of an objective and critical approach to material phenomena. It represents a change in the microcosm comparable to those in man's conception of the macrocosm, and displays a mind open to scientific facts, yet, in the words of Mr. Charles Coffin, refusing "to relax hold on the idea that the very nature of things in essence is an interpenetration of mind and matter." Donne is able in the face of the "paradoxical and seemingly contradictory suggestion of the physical and the spiritual, the material and the ideal, the manifestation of both the real and the unreal" to lay hold on the things of the spirit as the ultimate triumph of all knowledge and the goal toward which a seeming chaos might still point.

Donne's knowledge of the scientific discoveries of his times is evident both in his prose and poetry. In "Ignatius, his Conclave," Donne makes good use of his knowledge of astronomy; and in "Biathanatos," a discussion of suicide, he cites Kepler in refutation of St. Augustine's argument against innovation and shows his acceptance of the new philosophy by remarking that "the reason which moved Aristotle seems now utterly defeated." It is in his poems, however, that Donne's scientific information serves him with most illuminating effect. In the "Anniversaries," written on the death of Elizabeth Drury, a girl of fifteen, there are passages which are almost unintelligible except in the light of Donne's interest in the new science. He writes:

> And new Philosophy calls all in doubt,
> The Element of fire is quite put out;
> The Sun is lost, and th' earth, and no man's wit
> Can well direct him where to looke for it.
> And freely men confess that this world's spent,
> When in the Planets, and the Firmament
> They seeke so many new; they see that this
> Is crumbled out againe to his Atomies.
> 'Tis all in peeces, all cohearence gone;
> All just supply, and all Relation:

Again in the same poem he says:

We thinke the heavens enjoy their Sphericall,
Their round proportions embracing all.
But yet their various and perplexed course,
Observed in divers ages, doth enforce
Men to find out so many Eccentrique parts,
Such divers downe-right lines, such overthwarts,
As disproportion that pure forme: It teares
The firmament in eight and forty sheires,
And in these Constellations then arise
New starres, and old doe vanish from our eyes:

It is also in "The Anatomie of the World" that Donne refers to the new mineral drugs of Paracelsus.

In contrast with the melancholy tone of the lines quoted above are these from "Epithalamion" in which Donne refers to the idea that if it were true that the earth moved, whirling about in space, all that inhabited it would be in chaotic motion:

And were the doctrine new
That the earth mov'd, this day would make it true;
For every part to dance and revell goes.
They tread the ayre, and fal not where they rose.

Passion and melancholy are the chief characteristics of Donne's "Satires" and "Songs and Sonnets." His devotional poems, both those written before and those written after he took Orders, rank among the greatest contributions to this form of poetry. He was an innovator in style and form who "brought the toughest of intellectual disciplines to the expression of emotion." His influence has been more lasting than that of any other of the so-called metaphysical poets, extending to the present time.

Writing of Donne in an essay called "Donne and Today," George Williamson has this to say of his influence as it affects T. S. Eliot and other contemporary poets:

The great hold of Donne and the Elizabethans upon Eliot and other contemporary poets lies in this: they provide the greatest instance in our literature of poets moulding language to new developments of sensibility. For the metaphysical phase of this extension Donne created an idiom in which emotion is patterned by intellect, tightened up by reason, and salted by wit. . . . And Eliot's dictum that emotion is made precise and definite by intellect probably owes much to the study of Donne.

He says, too, that

in nothing are Donne and Eliot more alike than in the fact that each has taught his fellow poets to be contemporary. . . . To be contemporary in the right sense means to find the peculiar emotional tension of the time and to mould language to its expression. For Donne and Eliot this meant that each had to create a form adequate to contain the experience of a man who has awakened to the insufficiency of previous syntheses.

And here Mr. Williamson seems to touch upon the quality in Donne which attracts the modern reader—the struggle of a man who "has awakened to the insufficiencies of previous syntheses" to establish not only a means of expression for his resultant state of mind, but a soul-satisfying solution to his problem. If Donne's world were "all in peeces" as a result of the work of the sixteenth and seventeenth century scientists, so is ours from a somewhat different cause. If Donne found, through intuitive perception, the interrelation and interdependence of men, we have had the fact thrust upon us with such brutal realism that its more mystical implications overtake us almost unawares, and, though the issue may not result for us in a triumph of faith, it must make ever more evident to us that primitive cry of men for a "sure refuge," and bring with it an increasing consciousness of the brotherhood of men. So the personality and works of John Donne take on a new meaning for his twentieth century readers "for whom the bell tolls."

No man is an Island, intire of it selfe; every man is a peece of the Continent, a part of the maine; if a Clod bee washed away by the sea, Europe is the lesse, as well as if a Promontorie were, as well as if a Mannor of thy friends or of thine owne were; any mans death diminishes me because I am involved in mankinde; and therefore never send to know for whom the bell tolls; It tolls for thee.—JOHN DONNE, "The Devotions," Section 17.

BOOKS ON SCIENCE FOR LAYMEN

MATHEMATICS MADE HUMAN[1]

THIS is a highly successful popular presentation of certain ideas of modern mathematics. It departs from the usual trite popularizations of mathematics, whose purpose, as justly described by the authors, is "either to discuss [mathematics] philosophically, or to make clear the stuff once learned and already forgotten."

Each of the nine chapters either discusses some classical topic from a modern point of view, or deals largely with fairly new topics whose interest for mathematics as a whole has been appreciated only comparatively recently. All the topics selected amply sustain the authors' thesis that the imagination has played an important, sometimes decisive, part in the development of mathematics.

Avoiding the hack reviewer's pet cliché that "it is difficult to see for what class of readers the book is intended," we observe merely that it is not addressed to morons. There is something here for those who have gone no farther than counting in arithmetic; also something for those who have traveled so far that they are rather tired of mathematics, and wonder whether after all they would not have got more out of life by sharing a thoughtless peace of mind with their neighbors and the ever-tranquil cows. To the first class of readers the earlier chapters, leading from the simplest arithmetic to transfinite, transcendental and imaginary numbers, will be a revelation. Both classes will enjoy the chapters on topology, with their "rubber sheet geometry" and the incredible map described on page 297. An unscrupulous reader might take a considerable sum of money off his friends with that map. Nearly every one will be interested in the exposition of probability, for only the very best of us (or the most intelligent) never gamble. Such topics as non-Euclidean geometry raise the controversial question of the relation of mathematics to truth. As this contradicts Hardy's creed of the (Platonic) realism of mathematics we quote a part of what the authors report.

". . . we have overcome the notion that mathematical truths have an existence independent and apart from our own minds. It is even strange to us that such a notion could ever have existed. . . . To-day mathematics is unbound; it has cast off its chains. Whatever its essence, we recognize it to be free as the mind, as prehensile as the imagination."

Even though this humanized conception of mathematics may be blasphemy to some, it has the merit, unusual in mathematical philosophy, of making sense.

Though it is rather fatuous to wish this book (with its excellent typography, clear drawings and diagrams and full index) the success which it already has, we trust that it will have a long and prosperous career. It is something new, of its own kind, in the popularization of mathematics.

E. T. BELL

[1] *Mathematics and the Imagination.* Edward Kasner and James Newman. xiv + 380 pp. $2.75. 1940. Simon and Schuster, Inc.

THE STORY OF ELECTRICITY[1]

EVERY reader of this monthly knows the importance of electricity to-day and knows the names of its great pioneers—Edison, Brush and Elihu Thomson. But few know what colossal labors lie between an idea in the mind of an inventor and the convenient light on the desk or an electric locomotive. It was only sixty years from Thomson's day as a young instructor at the Boys' Central

[1] *Men and Volts.* John Winthrop Hammond. xii + 436 pp. $2.50. 1941. J. B. Lippincott Company.

High School in Philadelphia to a corporation with assets of 323 million dollars, from the days of gas lights and horse cars to a complete electric age, but the story of that transition is an epic of science, engineering, finance, management—in fact of pre-war America. It is fully as interesting and important in American history as is the winning of the West.

Just to prove how much more than technical invention is involved it is worth mention that in the 48 years of its existence the General Electric Company has sold approximately seven billion dollars worth of products, has paid nearly three billions in wages and salaries and 656 millions in dividends, and has more than two hundred thousand stockholders, besides fathering the Radio Corporation of America and those discoveries in pure science which can not be measured in dollars.

The original manuscript of this great official history ran to 300,000 words and was based on more than three years of painstaking research. It carried the story to 1922. But John Hammond died in 1934 and Arthur Pound edited and condensed the record to about one third and added a brief epilogue to cover recent years. The final thirty pages are a formal statement by Owen D. Young on the formation of the capital of the General Electric Company made to the Temporary National Economic Committee in 1939.

Thus the record of the first thirty years forms the bulk of this book, the days of leadership by Charles A. Coffin and of E. W. Rice, Jr., the two first presidents, and of the technical pioneers, Edison, Thomson, Brush, Wood and Steinmetz. It is of such interest to readers of to-day that one must hope that a similar dramatic story is now being prepared of the days since then, under the direction of Owen D. Young and Gerard Swope and the ideas of Whitney, Langmuir, Alexanderson, Coolidge and the Research Laboratory. That is already material for history, for now the company faces a great world-crisis under its third generation of executives, with Philip D. Reed as chairman and Charles E. Wilson as president. It is a thrilling continued story, showing just why and just how knowledge is power—when used with intelligence.

GERALD WENDT

METEOROLOGY FOR AVIATORS[1]

THE author's stated purpose of presenting such aspects of meteorology as are of importance to the aviator has been carried out successfully. Development of the subject-matter proceeds in a logical and orderly manner.

The first three chapters deal with the fundamental bases of synoptic work, namely, the collection of meteorological observations, instruments used and coding and charting of the observations. In chapters four to twelve are discussed pressure, temperature, humidity, density, visibility, atmospheric motions and condensation processes. Chapters thirteen to sixteen deal with air masses, convergence and divergence, frontal and other depressions and anticyclones and other pressure types. One of the most important parts is chapter seventeen, which treats of the practical phases of weather forecasting. Examples of synoptic situations presented in chapter eighteen are confined to the region of the British Isles which differ materially from American conditions, and leaves something to be desired for American readers. Chapter nineteen deals with the general circulation of the atmosphere and world climate; and the final chapter condenses the broad features of weather over the oceans and continents into remarkably small compass in a very satisfactory manner. That mathematics has

[1] *Meteorology for Aviators.* R. C. Sutcliffe. xiv + 276 pp. $4.00. 1940. The Chemical Publishing Company.

been kept to a minimum consistent with the requirements will be appreciated by the average student. A large number of comments, associating weather with flying conditions, will be found of practical assistance in the field of aviation. Those undertaking for the first time work in weather forecasting from synoptic charts will find the book a helpful guide.

While the more important features of the book are excellent, exception might be taken to some less important ones. Warm and cold anticyclones could be made more complete by considering the vertical extent of the circulation as associated with the vertical temperature distribution. Some workers at least might find the definition of secondaries not to their liking, especially when the criterion of depth of pressure at the centers is employed. It is noted also that the author has followed other writers of recent years in the use of the term isallobars in restricting its use to three-hour pressure falls, instead of making it applicable to falls of pressure in any stated interval of time.

In all, the author's contribution is a quite valuable addition to the literature.

R. H. Weightman

THE PROBLEM OF "SHELL-SHOCK"[1]

During World War I, much was heard of the alliteratively titled disorder called "shell-shock," a term which included virtually all mental disorders in soldiers. (The term, by the way, had and has no medical standing in this country, and was not used officially). It was recognized by medical men that certain soldiers, particularly when exposed to concussion by high explosives, developed certain symptoms generally labelled "neurotic," that is, largely due to psychological factors with only a minimum of structural damage—these states included, among others, hysterical paralyses, aphonia, tremors, stuttering, certain circulatory disturbances (effort syndrome) and anxiety states.

This group of so-called "functional nervous disorders" has not shown any tendency to decrease, thanks partly perhaps to the Government's very generous policy of paying compensation so long as the symptoms are retained. Indeed, even now, almost twenty-two years after the Armistice, over 35,000 veterans are being compensated for disorders of this type, at an average rate of about $50 per month!

Now another war is on, a war in which American soldiers, sailors and civilians may sooner or later be engaged. We read of the "bomb shocked" children of England, and of the indiscriminate bombing of civilians under conditions in which the individual is hardly in a position to fight back at the enemy.

The present volume is a study of the mental mechanisms of what the author terms the "traumatic neuroses of war." There are 24 brief case reports, dealing with patients who have proved resistant to treatment. The author is a competent psychoanalyst who has devoted long study to the problem and who has been able to avail himself of the dynamic methods of studying cases. Many of the considerations are theoretical and primarily of interest to the psychopathologist rather than to the non-medical reader.

The author defines trauma as an "external factor which initiates an abrupt change in previous adaptation"—a rather broad definition, compared with the generally accepted usage! He further defines a traumatic neurosis as "a type of adaptation in which no complete restitution takes place but in which the individual continues with a reduction of resources or a contraction of the ego" (p. 79). Among the examples of "traumata" Dr. Kardiner lists such

[1] *The Traumatic Neuroses of War.* Abram Kardiner. x + 258 pp. $3.50. 1941. Paul Hoeber, Inc.

discrepant moments as fatigue, a sudden pain, arteriosclerosis, skull fracture and brain tumor (p. 74). Such a wide range seems a bit inconsistent with describing the traumatic neurosis as a "highly specific syndrome" (p. 3)!

As for prognosis, the author is decidedly pessimistic, a fact perhaps attributable in part to his having observed only post-war patients and not having had actual combatant experience. Many rather "classical" cases occurring at the front during the World War (and in the present hostilities) cleared up promptly with relatively simple treatment. One can agree heartily with the author's arguments in favor of lump sum compensation for such cases, as against the instalment method—a method which all too often tends to superadd a "compensation neurosis."

The volume, which first appeared as a monograph in the Psychosomatic Medicine Series, represents a vast deal of study and thought on a most important topic. Whether or not one agrees with all the author's conclusions, it represents a valuable contribution to the literature, and should be read by every serious student of military psychiatry. A bibliography and index complete the volume.

WINFRED OVERHOLSER, M.D.

CULTURAL ANTHROPOLOGY[1]

THE original edition of this work was prepared to communicate "an elementary knowledge of culture history" and to forestall "the long and needless floundering" which the author had observed among students of cultural anthropology and other social sciences. Its immediate success and wide utilization—including a French translation employed as a text in South America as well as in France—proved that Professor Lowie was not mistaken in his estimate of the need. The volume took its place at once in the front rank of such publications. At the same time teachers of anthropology expressed a strong desire to have it amplified in certain directions, including the introduction of chapters on language and theory, as well as descriptions of typical cultures in their totality. Indeed, Part I of this work is practically identical with the original except for the addition of the two chapters mentioned, the increase from 365 to nearly 600 pages being due mainly to the introduction of case studies of nine typical cultures, though there is appended also a useful glossary of terms and a selected reading list.

The nine studies just mentioned perform the same function to Part I as a treatise on physiology in supplementing one on anatomy or as synthesis in grammar complements analysis. Discussions of material culture, social, esthetic and religious manifestations in general are, after all, dissections of the total life of a people. Industries, arts, social adjustments and relations to the cosmos, seen and unseen, do not exist in separate compartments. They function side by side, or rather confluently, in the very same human brains, and the differences which they manifest in different peoples are not merely variations in industries, arts, customs, institutions and beliefs *per se*, but variations in complexes of those activities and attitudes. Hence the importance of the studies which Professor Lowie has added to his new edition, and it must be said that they have been excellently selected and admirably epitomized in the necessarily limited space assigned to each.

It was evidently Professor Lowie's intention to show at one and the same time the diversity of human cultural expressions and the thread of unity running through them all. Forbearing to include a sketch of the Crow Indians on which he has written extensively, Professor

[1] *An Introduction to Cultural Anthropology.* Robert H. Lowie. 2nd edition. Illustrated. xxx + 584 pp. $3.50. April, 1940. Farrar and Rinehart, Inc.

Lowie has chosen two tribes from South America, one from North America, one from Australia, one from Africa, one each from Indonesia and Melanesia, one from Asia and one from Europe. Three of these may be said to illustrate cultures generally considered among the lowest or "most primitive," four may be described as intermediate, and the Asiatic and European examples bring us to the cultural, as well as the historical, vestibule of what we generally call "civilization." Selection of the Albanians furnishes a clever means of tying up all these with the "higher peoples" of western Europe, including ourselves, and to "Our Western Civilization" is directed a short, pithy apostrophe which may be said to point the moral of the cultural story—in no moralizing tone, however, but with the breadth of view, temperance and dignified restraint so characteristic of its author. Those who are familiar with Dr. Lowie's more popular volume "Are We Civilized?," a work deserving the distinction of a best seller among those who use their minds for some other purpose than to feed a preconception, will recognize the same spirit. His discussion of racialism is particularly timely and should prove convincing to all readers not eaten up with prejudice and oblivious to argument.

This is a work which may, and should, "introduce" cultural anthropology to many outside of the academic halls as well as those within them for whom it is particularly intended.

JOHN R. SWANTON

AMERICAN SNAKES[1]

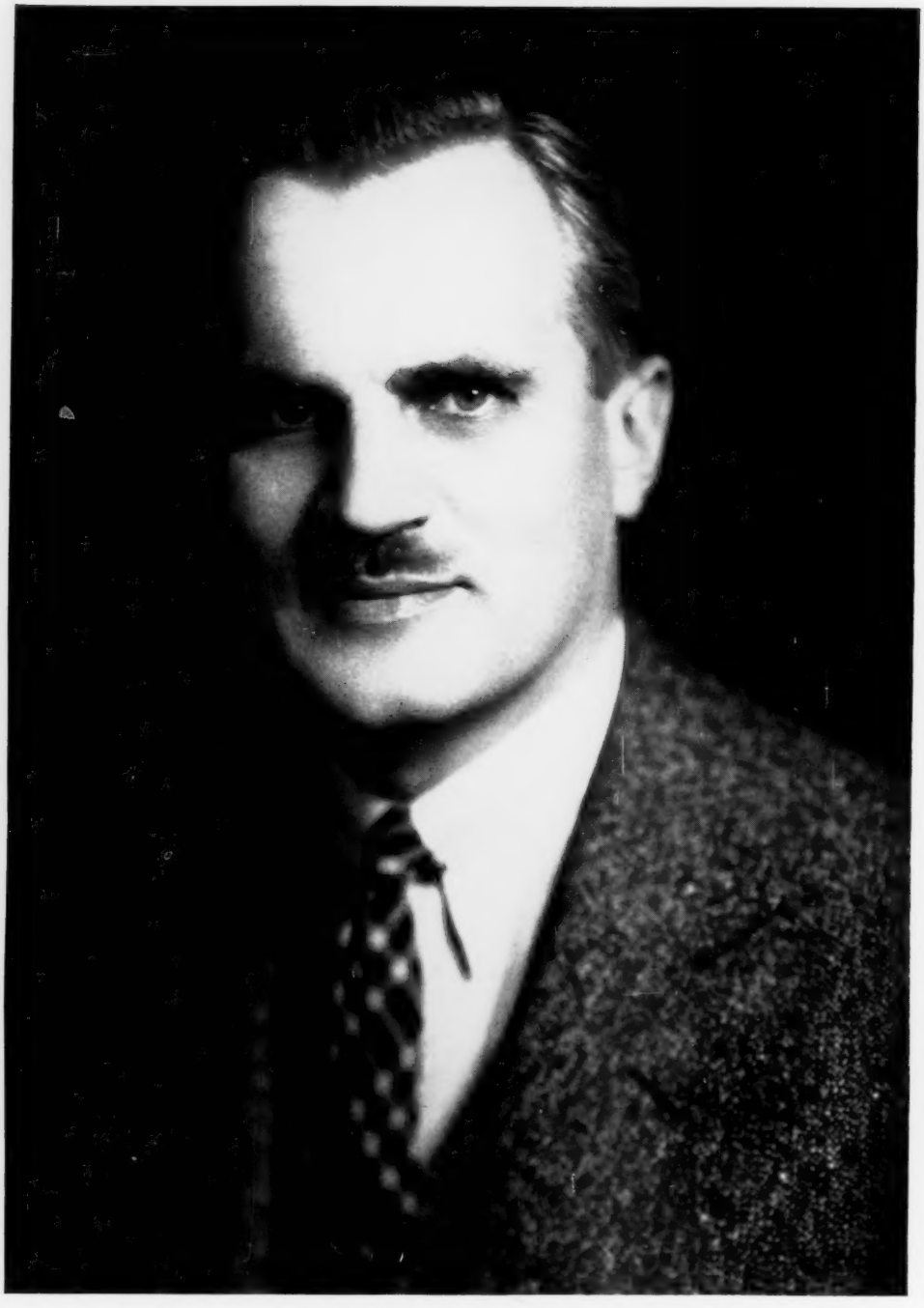
ALL America is divided into three parts, according to Ditmars' arrangement of the snakes. The work is really three handbooks in one. After a short reptile survey, an account of the habits and instructions for identifying snakes, come a chapter each on the northeastern, the southeastern and the western species, with simple, non-technical keys for identification and descriptions of each species, with notes on habits and distribution.

Identification of the species is greatly facilitated by a series of 48 plates with diagnostic photographs. These, partly the work of Ditmars himself and partly of his colleagues, are excellent. The treatment of snake bites, both in humans and domestic animals, is considered in an informative and broad-minded manner. The classified list of the snakes in North America includes scientific and common names and the distribution.

In general, this is a most useful book for the field naturalist and student of reptiles.

W. M. MANN

[1] *A Field Book of North American Snakes*. Raymond L. Ditmars. xii + 305 pp. 48 plates. $3.50. 1939. Doubleday, Doran and Company, Inc.



DR. ARTHUR H. COMPTON

CHARLES H. SWIFT DISTINGUISHED SERVICE PROFESSOR OF PHYSICS, THE UNIVERSITY OF CHICAGO; PRESIDENT-ELECT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE PROGRESS OF SCIENCE

NEWLY ELECTED PRESIDENT OF THE AMERICAN ASSOCIATION

In electing Professor A. H. Compton to the presidency of the American Association for the Advancement of Science, the association becomes headed by one typically representative of that reincarnation which physics experienced at the birth of the quantum theory.

Three decades ago classical spectroscopy, one of the most dignified representatives of formal empiricism, guarded carefully in the etiquette of scientific procedure by some of the most distinguished lights of the day who had no great love for speculation, was struggling in its bonds to participate in the feast of good things which the experimentalist was continually bringing forth from his investigational oven. The Bohr theory arrived, and all good physicists, who, at the time, were over half a century in age, while admiring the genius of the young upstart who had brought it forth, grumbled nevertheless among themselves and voiced strong fears concerning the road to intellectual ruin which their beloved science seemed to have taken. Photoelectricity had demanded a strong break with that past and the effect, whose discovery was Compton's first claim to fame —the Compton effect—marked the beginning of the new era in which the quantum theory sought satisfaction in its own laws rather than in some vague peculiarity of classical theory.

It was in 1931 that Compton entered a relatively new field by undertaking a geographical survey of the cosmic ray intensity, as a result of which a latitude effect, which had already been claimed by J. C. Clay, became confirmed by a very extensive set of observations. The result was that this effect, which formerly had only been partially accepted, became a fundamental element in the discussion of the nature of cosmic radiation.

Arthur H. Compton was born at Worcester, Ohio, on September 10, 1892. He received his B.S. degree from Worcester College in 1913 and his Ph.D. from Princeton in 1915. He became a member of the faculty of the University of Minnesota in 1916, and research physicist for the Westinghouse Lamp Company in 1917. In 1919 he went to Cambridge, England, for a year. He became professor of physics and head of the department at Washington University in 1920, and in 1923 he was elected professor of physics at the University of Chicago. He has countless medals, honorary degrees, and other distinctions to his credit, including the Rumford Gold Medal of the American Academy of Arts and Sciences, the gold medal of the Radiological Society of North America, the Matteucci gold medal of the Italian Academy of Sciences and the Franklin Institute gold medal. He was awarded the Nobel Prize for Physics in 1927. He is a member of numerous scientific societies, including the American Physical Society, of which he was president in 1934, the American Philosophical Society and the National Academy of Sciences.

In addition to his multitudinous activities as a physicist, Compton finds time to participate in the social activities of his community, particularly those associated with the church. He is a man of strong athletic build and can put up a hot game of tennis at any time.

A delightful friend and a man of broad interests, he should provide the American Association with a president well calculated to represent its best traditions.

W. F. G. Swann

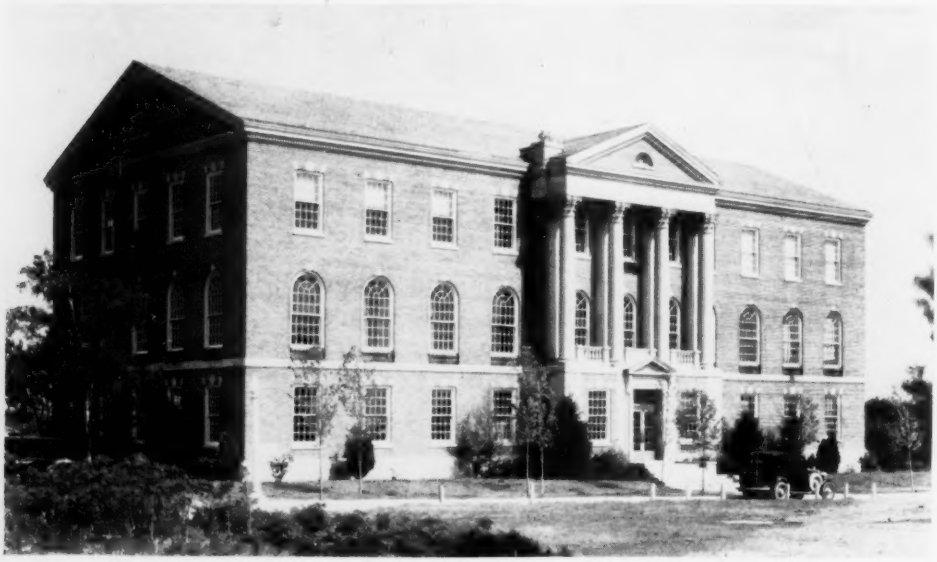
THE AMERICAN ASSOCIATION—AN INTEGRATING AGENCY IN SCIENCE

PERHAPS the most distinctive and important function of the American Association for the Advancement of Science is to serve as an integrating agency in the ever-increasing specialization in science. Never has the value of this function been more emphatically illustrated than during the meeting it held in Dallas, Texas, from last December 29 to January 3.

Dr. Albert F. Blakeslee, retiring president of the association, took for the title of his presidential address "Individuality and Science." In announcing this subject a year ago he proposed a general theme, a *leit motif*, that he hoped would appear again and again in the program, as it did. It emphasizes the distinctiveness of the individual, whether it be on the human level or that of the lowliest organism, or in the snowflake or other crystal. It is a universal characteristic of the units with which science is concerned and adds dignity to the individual in spite of similarities which are at the basis of science. It is a unifying generality derived from individual diversities.

Many less sweeping integrations were made in the 193 sessions which were held for the delivery of addresses and the presentation of papers, of which there were 1,436 in the few crowded days of the meeting. The most conspicuous were the symposia in which a number of distinguished authorities joined in discussing the various aspects of some broad field of science and set forth a unified whole which in importance and comprehensibility is much greater than the sum of its parts. It is such integrations that the association has published in its symposia volumes which have been on such subjects as cancer, mental health, human malaria and the heart, to mention only a few in the field of public health.

There is a reason why the mingling of men of somewhat different points of view is important. Excessive specialization leads to sterility, whether it be in the

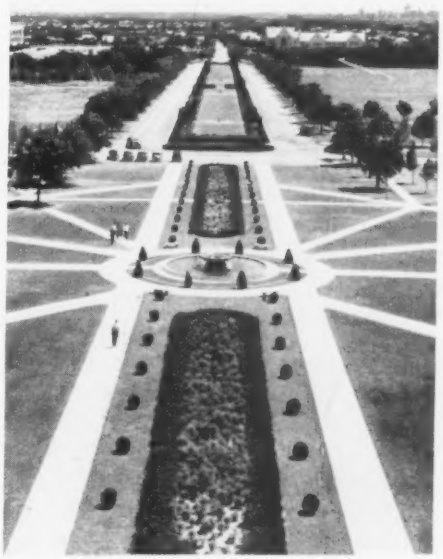


HYER HALL OF PHYSICS OF THE SOUTHERN METHODIST UNIVERSITY
WHERE SOME OF THE PHYSICS AND ASTRONOMY SESSIONS WERE HELD; SEVERAL ASSOCIATED SOCIETIES ALSO MET IN THIS BUILDING.

field of living organisms or in the field of ideas. Often highly specialized plants, as apple trees, for example, are incapable of fertilizing their own blossoms, and to produce fruit must obtain pollen from other and often inferior varieties. How often has a somewhat similar thing happened in a culture or a philosophy or a religion! Decadence is overspecialization. The hundreds of thousands of extinct species of plants and of animals are probably mostly examples of it.

The American Association for the Advancement of Science brings together specialists from practically all the broad fields of the natural and the social sciences. Its fifteen sections organize varied programs and its 186 affiliated and associated societies represent many points of view and specialized interests. If any one over-values his own subject in such an environment, he is likely to get his bias corrected. If he is unaware of the broad currents that are sweeping along in fields other than his own, he is likely to be enlightened. If he is groping for unifying ideas in his specialty, he stands a good chance of discovering a clue to them in some related subject.

In addition to these fortuitous fruitful contacts that are always highly valued by those who attend meetings of the association, there are the deliberately planned joint programs of related sections and societies. Sometimes groups that are clearly related in interests meet together. For example, the zoologists and the botanists united at Dallas in discussing the effects of temperature on evolution. In other cases scientists with generally quite different interests find that special sectors of their fields are complementary. For example, at Dallas the Section on Geology and Geography, the Geological Society of America and the Section on Anthropology united in a symposium on "Early Man." Sometimes a number of different societies unite in considering a subject of almost universal interest, as when the Botanical Society of America, the American Society of Naturalists, the American Society of Zoologists and the Genetics Society of America joined in a symposium on "Human Genetics." In the subject of genetics, perhaps more explicitly and illuminatingly than in any other, are the common properties of all life, whether plant or animal, brought into the light. Under the broadening effects of contemplating such unities in the organic world the pages of the history of the earth are turned back across the geologic ages to the ancient origins of the streams of life which have come down to our day. In such reflections the scientist acquires both humility and serene dignity, for he realizes that he is not some darling of the gods but an evolving organism to whose future



CENTRAL CAMPUS QUADRANGLE
AT SOUTHERN METHODIST UNIVERSITY WITH THE DALLAS SKYLINE IN THE BACKGROUND.

achievements no limits can be set. He daily increases his understanding of the general processes of evolution and even aspires to mark out, perhaps in a still distant future, a glorious pathway that his successors may follow.

F. R. MOULTON,
Permanent Secretary

THE AMERICAN ASSOCIATION PRIZE FOR 1941–1942

THE award of the A.A.A.S. prize for 1941–1942 to Drs. Frank H. Johnson, Dugald E. S. Brown and Douglas A. Marsland is a happy example of the results which can be attained by cooperation in somewhat diverse fields. Ever since Dr. Johnson's graduate student days at Princeton, he has been an enthusiastic and painstaking student of luminous bacteria. He has studied their food requirements, their respiration and their luminescence as affected by temperature, narcotics and various poisons. He has become an expert in culturing them, measuring their light intensity and interpreting the complicated series of reactions which are responsible for the luminescence. He is now assistant professor of microbiology at Princeton University.

Drs. Brown and Marsland have long been associated in the study of the effects of high pressures on various cells and cell processes. These studies have had to do with muscle contraction, amoeboid movement, cell division and the viscosity of cells. In the investigation of these processes they have perfected many ingenious devices for observing and recording under high pressure. Dr. Brown is professor of physiology and Dr. Marsland, assistant professor of biology at New York University.

It is surprising that so little attention has been paid to living cells under pressure, since pressure is just as important as temperature in defining a chemical equilibrium. Since the early experiments of Regnard in 1884, which were stimulated by the dredging expedition of the ship *Talisman*, that found living animals at great depths, practically no work on pressure has been carried out until Edwards and Cattell in 1927 began their series of observations on the heart and cardiac function. Since then pressure has become increasingly important in biology, largely through the notable discoveries of Brown and Marsland.

A most necessary procedure in biological research is to select the proper material. One of the great advantages of luminous bacteria is the opportunity they offer to follow a chemical reaction in the living cell without removing samples from time to time for analysis. This is because the light intensity of the bacteria is a measure of reaction velocity, the rate at which a chemical reaction proceeds. We have in these bacterial test-tubes a series of reactions whose rate can be automatically and continuously followed by recording the luminescence. The primary reaction is the oxidation of a substance, luciferin, by the enzyme, luciferase. Like every other chemical reaction, this light-emitting one proceeds faster as the temperature rises, but soon a certain temperature is reached where it slows, and as the temperature rises still further the rate (*i.e.*, light intensity) becomes less and less and finally practically ceases. If the temperature is now lowered, the light again returns. The temperature effect is reversible within certain limits.

However, a striking thing happens if the hydrostatic pressure is increased at a temperature where the light has been considerably dimmed. The luminescence increases and returns to practically its original brightness without lowering the temperature. The pressures which do this are not super-pressures, such as

occur in stars or even the highest pressures attainable in the laboratory, but a mere 5,000 pounds per square inch such as occurs two miles deep in the ocean, where many shrimp and fish live permanently.

This effect of temperature and pressure on luminescence can be explained by an effect on two chemical processes, the increase in velocity of the luciferin-luciferase reaction with increase in temperature and the reversible denaturation of the enzyme luciferase as the temperature rises. In this reversible denaturation the luciferase molecules become larger. Pressure restores them to their original size; it reverses the denaturation equilibrium and the original luminescence intensity returns. These changes are without doubt applicable to practically all biological effects of temperature and follow from the newer knowledge of absolute reaction rates, predictable from quantum mechanics by the work of Eyring and his collaborators.

A second remarkable finding of the A.A.A.S. award group has to do with the effect of pressure on the narcosis of luminous bacteria. The light of luminous bacteria which has been nearly quenched by some such narcotic as ether, chloroform or procaine can be restored again by increasing the pressure. The explanation is the same as that for the effect of temperature, a reversible denaturation of the luciferase by the narcotic which again involves an increase in molecular volume. Pressure restores the original volume. This finding is also of general importance and applicable to narcosis of nerve cells and other types of biological activity.

These brief statements give an idea, all too inadequate, of the basic goal of Johnson, Brown and Marsland, the use of luminescence, temperature and pressure to analyze cell reactions. Although luminescence is the function actually studied I should like again to emphasize the wide significance of their results. Biologists in all fields will join in extending hearty congratulations to the prize winners along with the hope that they will continue to apply these tools to the further elucidation of life processes.

E. Newton Harvey

ENGINEERING AND INDUSTRIES SECTION OF THE NEW "INDEX EXHIBIT" OF THE SMITHSONIAN INSTITUTION

The semicircular alcove of Cultural Anthropology described in the December, 1941, issue of the Scientific Monthly, faces a similarly shaped alcove devoted to engineering and industries. This part of the exhibit illustrates the work of the engineering and industrial divisions of the National Museum. These divisions, aside from maintaining popular educational exhibits, have the function of preserving adequate collections of original machines, inventors' models and experimental mechanisms which trace the progress of our industries and our machine economy.

The theme center of the alcove calls attention to the impact upon the world's social and economic pattern made by the large-scale use of the energy resources of fuels and water power. It shows rulers commanding the energy of hordes of toiling slaves to build the pyramids and by way of contrast a handful of skilled operators directing mechanical or electrical energy into the machines by which they are building structures surpassing the pyramids in volume alone. The modern structures shown are dams which will in turn produce more hydro-electric energy to free more people from back-

THE ENGINEERING AND INDUSTRIES ALCOVE
OF THE SMITHSONIAN INSTITUTION'S INDEX EXHIBIT. TO THE LEFT ARE EXAMPLES OF CREATIVE AND INTENSIVE INVENTIONS. THE LARGE MODEL IN THE CENTER IS OF THE NEWCOMEN STEAM ENGINE. TO THE RIGHT ARE EXAMPLES OF INVENTIONS IN AGRICULTURE.

breaking toil and give them the relative freedom of working with their minds and skills. Between these illustrations is an operating model of the machine which was practically the original instrument to inaugurate the application of fuel energy to mechanical work—the Newcomen steam engine of 1712. Its timbered walking beam jerks through the motion of lifting the rods of pumps raising water from an English coal mine. The original engine was the first machine capable of putting to work the energy released from any considerable amount of fuel. A contemporary model of the Newcomen engine was James Watt's introduction to the elementary problems of efficiently using the power of steam which he so ably solved. It is difficult to overestimate the importance of the Newcomen engine in the recent history of the world.

NEWCOMEN STEAM ENGINE OF 1712
THE ENGINES AND MACHINES THAT HARNESS THE ENERGY RESOURCES OF THE EARTH BEGAN AS SIMPLY AS THIS EARLY STEAM ENGINE.

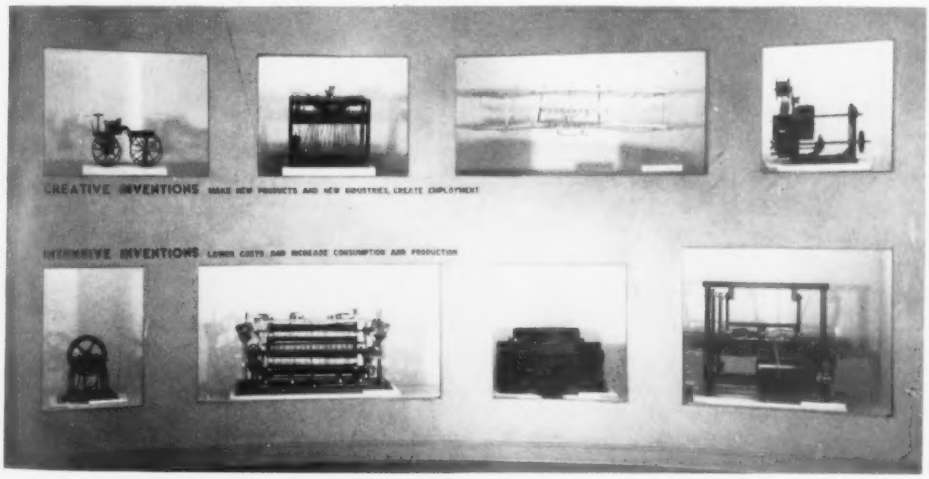
In times of unrest, particularly during economic disturbances, much criticism is directed at the inventor and the engineer for their parts in the development of machines and processes that displace the laborer and craftsman. Without direct reference to this question or its answer, two groups of original models and actual old devices representing inventions are displayed. One group represents the creative inventions which have created vast new industries and multiplied the opportunities for employment many times. These include an original Armat motion picture projector, the patent model of the Selden automobile, a model of the Wright airplane of 1903, and the

INVENTIONS IN AGRICULTURE

Top, ORANGE-SIZING APPARATUS (1881); GRAIN DRILL (1882); SUPPORTER FOR STEEL PLOW (1877); VEGETABLE SORTER (1879); MOWING MACHINE (1878); STRAW CUTTER (1878). *Bottom*, STEEL PLOW (1838); CORN PLANTER (1861); GRAIN HARVESTER (1878); GRAIN DRILL (1879); SULKY CULTIVATOR (1891).

patent model of the Sholes, Glidden and Soule typewriter of 1868.

The second group represents the so-called intensive inventions. These are the tools that have multiplied the productive capacity of the individual, and though they have immediately displaced workers, they have often lowered costs so much that consumption has increased greatly enough to require a greater employment to accomplish the necessarily increased production. These include an


CREATIVE INVENTIONS MAKE NEW PRODUCTS AND NEW INDUSTRIES, CREATE EMPLOYMENT
INTENSIVE INVENTIONS LOWER COSTS AND INCREASE CONSUMPTION AND PRODUCTION

EXAMPLES OF CREATIVE AND INTENSIVE INVENTIONS

Top, SOME OF THE CREATIVE INVENTIONS, WHICH MAKE NEW PRODUCTS AND INDUSTRIES AND CREATE EMPLOYMENT: SELDEN AUTOMOBILE (1879–1895); SHOLES TYPEWRITER (1868); WRIGHT AIRPLANE (1903); ARMAT MOTION PICTURE PROJECTOR (1897). *Bottom*, SOME OF THE INTENSIVE INVENTIONS, WHICH LOWER COSTS AND INCREASE CONSUMPTION AND PRODUCTION.

original Thomson electric welder, Howe's own model of his sewing machine, the G. Crompton loom and the Blanchard copying lathe.

These groups are exhibited in two parallel rows of small openings on one side of the alcove. On the opposite side is a large group of models representing the application of the machine to a field classically associated with hard human labor, namely—agriculture. In this case the original Deere plow of 1838 stands in somewhat battered simplicity in contrast with the nicely finished patent models of more complicated agricultural tools. These include a fruit sizer, a vegetable sorter, harvesters, mowers and many other machines that now, in combination with the internal combustion engine and the rural electric power line, are extending the advantages of the nation's energy resources to the farmer.

FRANK A. TAYLOR

MEDICAL-PHYSICS LABORATORY OF THE UNIVERSITY OF CALIFORNIA

A MODERN research plan, designed for greater cooperation than ever before among scientists trained in many specialized fields, is being developed at the University of California to explore the promising new fields by the atom-smashing cyclotron. To carry out this plan, the first medical-physics laboratory in the world will be built on the Berkeley campus, and a five-man team of scientists will form the nucleus of a unique new research division.

The plan is a recognition that the body of scientific knowledge is becoming so great and the various branches so closely interwoven that one man can not possibly cope with all the problems he will encounter in a single complex experiment. With the new facilities being provided, the university will make it possible for from ten to fifty specialists to concentrate on a single problem at one time. The new laboratory will represent a union of physics and medicine and other branches of science, such as chemistry, bacteriology, biology and genetics.

The new laboratory will intensify experimental work in the vast new fields

ARCHITECT'S DRAWING OF THE NEW MEDICAL-PHYSICS LABORATORY
THE BUILDING WILL BE DEVOTED ENTIRELY TO RESEARCH WORK.

of science opened by the cyclotron, such as the study, with radium-like substances, of the normally functioning living body and the manner in which it absorbs foods; the investigation of the causes of various diseases, including cancer and leukemia, with radioactive substances and with the neutron beam produced by the cyclotron; the exploration of rudimentary life processes, including photosynthesis, the method by which green plants store the energy necessary for life on earth, and, cell division, or elementary reproduction.

The research program will be made possible by two important donations reported recently by the president of the University of California, Robert Gordon Sproul: First, a gift of $165,000 to build and equip the building from the International Cancer Research, of which M. W. H. Donner is president. Second, a contribution of $50,000 from the Columbia Foundation of San Francisco to support for five years a five-man research team. Support by the Columbia Foundation will enable the university to organize and keep together for the first time a group of workers in the new field of medical physics.

The research plan is being mapped [illegible] Dr. John H. Lawrence, who is in charge of medical investigations with the cyclotrons on the Berkeley campus. He will apply the instrument invented by his brother, Professor E. O. Lawrence, Nobel Prize winner, to medicine and biology.

The new sciences developed by the cyclotron call for close cooperation of men highly trained in a number of fields. To make possible a more effective combination of this scientific talent, a new laboratory of medical physics will have specialized facilities for the new building.

The Medical Physics Laboratory will be devoted entirely to experimental research. No treatment will be given there. Facilities will include [illegible]

original Thomson electric welder, Howe's own model of his sewing machine, the G. Crompton loom and the Blanchard copying lathe.

These groups are exhibited in two parallel rows of small openings on one side of the alcove. On the opposite side is a large group of models representing the application of the machine to a field classically associated with hard human labor, namely—agriculture. In this case the original Deere plow of 1838 stands in somewhat battered simplicity in contrast with the nicely finished patent models of more complicated agricultural tools. These include a fruit sizer, a vegetable sorter, harvesters, mowers and many other machines that now, in combination with the internal combustion engine and the rural electric power line, are extending the advantages of the nation's energy resources to the farmer.

FRANK A. TAYLOR

MEDICAL-PHYSICS LABORATORY OF THE UNIVERSITY OF CALIFORNIA

A MODERN research plan, designed for greater cooperation than ever before among scientists trained in many specialized fields, is being developed at the University of California to explore the promising new fields by the atom-smashing cyclotron. To carry out this plan, the first medical-physics laboratory in the world will be built on the Berkeley campus, and a five-man team of scientists will form the nucleus of a unique new research division.

The plan is a recognition that the body of scientific knowledge is becoming so great and the various branches so closely interwoven that one man can not possibly cope with all the problems he will encounter in a single complex experiment. With the new facilities being provided, the university will make it possible for from ten to fifty specialists to concentrate on a single problem at one time. The new laboratory will represent a union of physics and medicine and other branches of science, such as chemistry, bacteriology, biology and genetics.

The new laboratory will intensify experimental work in the vast new fields

ARCHITECT'S DRAWING OF THE NEW MEDICAL-PHYSICS LABORATORY
THE BUILDING WILL BE DEVOTED ENTIRELY TO RESEARCH WORK.

of science opened by the cyclotron, such as the study, with radium-like substances, of the normally functioning living body and the manner in which it absorbs foods; the investigation of the causes of various diseases, including cancer and leukemia, with radioactive substances and with the neutron beam produced by the cyclotron; the exploration of rudimentary life processes, including photosynthesis, the method by which green plants store the energy necessary for life on earth, and, cell division, or elementary reproduction.

The research program will be made possible by two important donations reported recently by the president of the University of California, Robert Gordon Sproul: First, a gift of $165,000 to build and equip the building from the International Cancer Research, of which M. W. H. Donner is president. Second, a contribution of $50,000 from the Columbia Foundation of San Francisco to support for five years a five-man research team. Support by the Columbia Foundation will enable the university to organize and keep together for the first time a group of workers in the new field of medical physics.

The research plan is being mapped by Dr. John H. Lawrence, who is in charge of medical investigations with the cyclotrons on the Berkeley campus. He will apply the instrument invented by his brother, Professor E. O. Lawrence, Nobel Prize winner, to medicine and biology.

The new sciences developed by the cyclotron call for close cooperation of men highly trained in a number of fields. To make possible a more effective combination of this scientific training, the new laboratory of medical physics will have specialized facilities for all in one building.

The Medical Physics Laboratory will be devoted entirely to experimental research. No treatment will be carried on there. Facilities will include chemical, physical, biological and biochemical laboratories, three dark rooms, an incubator room, a tissue culture laboratory and two underground rooms where delicate measurements of radioactivity can be carried out with electroscopes, Geiger counters and electrometers.

RADIOGRAPH OF LEAVES AND STEM OF A TOMATO PLANT WHICH HAD PREVIOUSLY TAKEN UP RADIOACTIVE PHOSPHORUS AS DISODIUM PHOSPHATE THROUGH THE ROOTS. THE PHOTOGRAPHS WERE TAKEN BY DR. PERRY STOUT.

The entire second floor, except for a library and a seminar room, will be turned over to physicists who will be working with the giant 4,900-ton cyclotron now being constructed on the Berkeley campus.

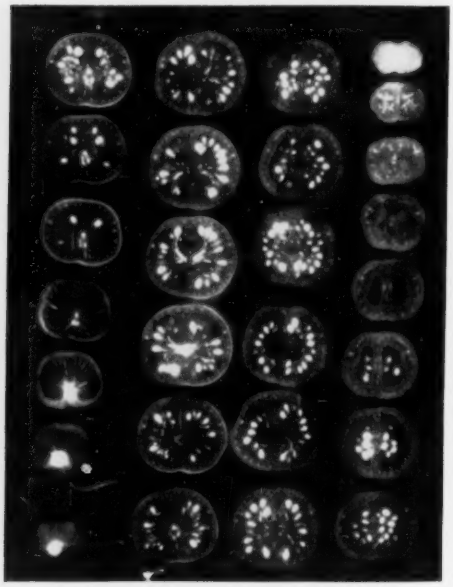
The building will have 16,000 square feet of floor space and will be 45 feet wide and 160 feet long. It will be situated just north of the mining building on the University Campus, its main entrance opening to the south and another entrance opening on Gayley Road.

Support for the five-man research team

will begin next July 1. This unit will consist of a clinical investigator, Dr. John H. Lawrence, assistant professor of medicine; a radiologist, Dr. Robert S. Stone, professor of roentgenology in the Medical School; a medical chemist, Dr. Joseph G. Hamilton, research associate in the Radiation Laboratory and clinical instructor in neurology in the Medical School; an animal biologist and geneticist, Dr. Alfred G. Marshak, research associate in the Radiation Laboratory; and a physicist trained in biology, Dr. Paul C. Aebersold, research associate in roentgenology and research associate in the Radiation Laboratory.

The primary tools in the new experimental program will be the radioactive substances produced by smashing atoms in the cyclotron. These substances are said to be the most valuable research tool since the development of the microscope.

Radioactive elements have all the ordinary properties of their stable counterparts in the periodical table, except that their atoms explode eventually, emitting a ray. Therefore the radioactive atoms, until the moment of their disintegration, are used in chemical reactions and by the human and animal body just as ordinary elements are used. For example, the body uses radioactive sodium precisely as it uses ordinary sodium. The atoms of ordinary molecules can not be followed individually, but the radioactive elements act as beacons for the investigator, for distribution in the body can be traced by sensitive intruments which record the exploding atoms.



THIN SLICES OF TOMATO FRUIT

A SERIES OF RADIO-AUTOGRAPHS FROM A TOMATO PLANT WHICH HAD PREVIOUSLY ASSIMILATED A COMPOUND OF RADIATED ZINC.

Radioactive elements are called isotopes of ordinary elements. More than 360 have been produced, and more than 100 of these were discovered in the University of California Radiation Laboratory. About a score of them have proved valuable in biological studies.

No previous method has been available for tagging the elements and compounds used by normal living organisms, and as a result, definite knowledge about metabolism was only fragmentary. Possibilities opened up by radium-like substances produced in the cyclotron are limitless. Already researchers at the University of California and in other laboratories have demonstrated that some of the accepted theories of body function were erroneous.

The three dark rooms in the new building will be used principally for taking radio-autographs; these "self-photographs" are employed to demonstrate the distribution of radioactive elements in the tissues of animals and plants. In this technique the animal is fed a radio-element, sacrificed, and the tissue in which the distribution of a radio-element is to be determined is placed on a photographic plate. The exploding atoms expose the film, and thus is secured a picture of the actual distribution of the

tagged element or compound in the tissues.

Representative of the Berkeley Radiation Laboratory's accomplishments with tagged atoms are the following: It has been demonstrated that the enzymes of the body break down minerals and other food components much faster than had previously been supposed. For example, calcium is found in the milk of cows within a few minutes after the mineral is consumed; formerly it was assumed that this process took days. Long standing theories of plant nutrition have been refuted. Plants can draw food directly from soil particles; the food does not need to be dissolved into a solution.

By using radioactive carbon it has been shown that plants can take up carbon dioxide without the presence of light. Radioactive strontium, a substitute for calcium, has enabled the Berkeley scientists to study the growth of teeth and bones and the migration of calcium from the mother to the offspring. Many unsolved problems surrounding the metabolism of the thyroid gland have been solved by the use of radioactive iodine. The metabolism of single cells is being studied with radioactive salts.

The new laboratory will make possible more extensive studies into the causes of disease such as cancer and leukemia, and further the development of new treatments for various diseases using irradiation methods. JOSEPH G. HAMILTON

THE WORK AND PERSONALITY OF WALTHER NERNST

I ACCEPT with pleasure the invitation of the editors of this magazine to dedicate a few lines to the scientific personality of Dr. Walther Nernst, who died recently. For he was one of the most characteristic and most interesting scholars with whom I have been closely connected during my life. He did not miss any of the conferences on physics in Berlin, and his brief remarks gave evidence of a truly amazing scientific instinct combined both with a sovereign knowledge of an enormous volume of factual materials, which was always at his command, and with a rare mastery of the experimental methods and tricks in which he excelled. Although sometimes goodnaturedly smiling at his childlike vanity and self-complacency, we all had for him not only a sincere admiration, but also a personal affection. So long as his egocentric weakness did not enter the picture, he exhibited an objectivity very rarely found, an infallible sense for the essential, and a genuine passion for knowledge of the deep interrelations of nature. But for such a passion his singularly creative productivity and his important influence on the scientific life of the first third of this century would not have been possible.

He ascended from Arrhenius, Ostwald and Van't Hoff, as the last of a dynasty which based their investigations on thermodynamics, osmotic pressure and ionic theory. Up to 1905 his work was essentially restricted to that range of ideas. His theoretical equipment was somewhat elementary, but he mastered it with a rare ingenuity. I refer, for instance, to the theory of electromotive powers in solutions of locally variable concentration, the theory of diminution of the solubility by adding a dissolved substance. During this period he invented the witty null-method of determining the dielectric constant of electrically conducting bodies by means of Wheatstone's Bridge (alternating current, telephone as indicator, compensating capacity in comparison-bridge branches).

This first productive period is largely concerned with improving the methodology and completing the exploration of a

field the principles of which had already been known before Nernst. This work led him gradually to a general problem which is characterized by the question: Is it possible to compute from the known energy of the conditions of a system, the useful work which is to be gained by its transition from one state into another? Nernst realized that a theoretical determination of the transition work A from the energy-difference U by means of equations of thermodynamics alone is not possible. There could be inferred from thermodynamics that, at absolute zero, the temperature of the quantities A and U must be equal. But one could not derive A from U for any arbitrary temperatures, even if the energy-values or differences in U were known for all conditions. This computation was not possible until there was introduced, with regard to the reaction of these quantities under low temperatures, an assumption which appeared obvious because of its simplicity. This assumption is simply that A becomes temperature-independent under low temperatures. The introduction of this assumption as a hypothesis (third main principle of the theory of heat) is Nernst's greatest contribution to theoretical science. Planck found later a solution which is theoretically more satisfactory; namely, the entropy disappears at absolute zero temperature.

From the standpoint of the older ideas on heat, this third main principle required very strange reactions of bodies under low temperatures. To pass upon the correctness of this principle, the methods of calorimetry under low temperatures had to be greatly improved. The calorimetry of high temperatures also owes to Nernst considerable progress. Through all these investigations, as well as through many stimulating suggestions with which his untiring inventive genius supplied experimenters in his field, he promoted the research work of his generation most effectively. The beginnings of the quantum theory were assisted by the important results of those calorie investigations, and this especially before Bohr's theory of the atom made spectroscopy the most important experimental field. Nernst's standard work, "Theoretical Chemistry," offers, not only to the student but also to the scholar, an abundance of stimulating ideas; it is theoretically elementary, but clever, vivid and full of intimations of manifold interrelations. It truly reflects his intellectual characteristics.

Nernst was not a one-sided scholar. His sound common sense engaged successfully in all fields of practical life, and every conversation with him brought something interesting to light. What distinguished him from almost all his fellow-countrymen was his remarkable freedom from prejudices. He was neither a nationalist nor a militarist. He judged things and people almost exclusively by their direct success, not by a social or ethical ideal. This was a consequence of his freedom from prejudices. At the same time he was interested in literature and had such a sense of humor as is very seldom found with men who carry so heavy a load of work. He was an original personality; I have never met any one who resembled him in any essential way.

ALBERT EINSTEIN